Worldmaking as Techné

Participatory Art, Music, and Architecture

Edited by Mark-David Hosale, Sana Murrani, and Alberto de Campo with a Foreword by Roy Ascott

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Foreword

At the midpoint of 20th century culture, in the slipstream of the intellectual momentum established most notably by Ross Ashby, Gregory Bateson, and Heinz von Forster, the word *cybernetics* was introduced into the world of art, radically affecting, over the long term, both art theory and art practice. At once a provocation and a prophesy, the word enabled the values of process and system to enter the perception and practice of artists, who were otherwise immersed in the stasis of object and structure. Indeed, the 1943 paper by Rosenblueth, Wiener, and Bigelow, "Behavior, Purpose and Teleology" was prescient in relation to the move in art and architecture towards behaviour concerned that not only what an artwork or building could do, but what the viewer or user can do to make it do it!

This book is essentially about doing, set in the context of technological and ontological becoming ... of new forms, new behaviours, new meanings. It is a book that witnesses the triumph of theory on the move, of worlds in emergence, of the malleability of mind and matter. Such processes of perceptual plurality, the fluctuation of form, the generation of multiple meaning, calls for semantic interplay and physical interaction that have institutional and ontological consequences: institutionally, in that the technology of art demands the revisioning and restructuring of the architecture of encounter, that is the post-gallery, moistmedia museum environment; and ontologically in the reframing of thought and theory, at all levels of human encounter, whether singular and intimate or social and public.

Here we have a book that speaks of the poetry of change in sync with the technology of desire, where computational inspiration meets with the fertility of the creative organism, whether behaviourally performative or structurally adaptive, and always in the frame of advanced ontological engineering. As a consequence of the interactional element in their evolution, art and architecture, like the advanced technology to which they turn, have come to be seen, and above all created, as instruments of the individual user's desire, rather than simply users of common cultural tropes, as past decades determined. The artwork, as process and system, offers interaction with multiple worlds, new universes of mind and media. Art, as we read here, has become a worldmaking process, architecture has become subtly semiotic and serially transformative.

Worldmaking necessarily involves word making: new terms of technique are required, new phrases of creation are called for, the whole vocabulary of becoming requires critical and theoretical renewal and redescription, a demand that this book celebrates in excelsis - a book about worldmaking by worldmakers exhibiting not only aesthetic innovation but technological sense and social sensibility.

– Roy Ascott.

Introduction from the editors

While the three editors of this volume have disparate practices that fall into the domains of art, music, and architecture, the conceptual thinking and the methodology that drives our practices transcends medium or discipline. This commonality can be traced to the foundation of technology in our work. Technology-based work is inherently interdisciplinary. Stemming from the digital, modern technology provides humankind with the ability to encode all information and its representation using the same binary system as a basis. It has a tendency to be algorithmically executed, runtime, and adaptive to change. As a result, technology-based works commonly feature notions of participation, perception, interaction, user experience, and immersion in its outcome.

Beyond the use of technology, we found common-ground in the desire to maintain a close-knit relationship between philosophy and methodology in our practice. In our work, philosophical concepts are manifested in the methods for the creation of work, as much as they are embodied in the content of work itself. In our work we see the process from creation to presentation as part of a continuum. To describe this relationship we found the term techné (τέχνη). Techné is an ancient philosophical concept that has been debated by philosophers such as Aristotle, Xenophon and Plato, as well as more contemporary philosophers such as Guattari and Heidegger. In simplified terms the concept of techné is concerned with the art and craft of making, but the extended meaning implies a discussion of the significance of the work, including *how* and *why* something is made.

For Aristotle, techné (which literally means *art* or *skill*[1]) is not simply concerned with the craft of making. Along with *episteme* (knowledge), *phronesis* (judgment), *sophia* (wisdom), and *nous* (intellect), techné is one of *the five qualities through which the mind achieves truth in affirmation or denial*[2]. Techné is also key in the completion of the *hexis* of a virtuous person[3]. As Aristotle stated, *art is the same thing as a rational quality, concerned with making, that reasons truly*[4].[5] From this definition one can understand techné as a mode of rationalization capable of concept forming, and is a form of discourse in its own right.

[1] Merriam-Webster. 2017. "Dictionary and Thesaurus - Merriam-Webster Online." *Encyclopedia Britanica.*

http://www.merriam-webster.com/dictionary/techne (accessed June 28, 2017)

[2] Aristotle. *Nicomachean Ethics*. Rev. ed. Edited by H. Rackham. Loeb Classical Library. Cambridge, MA: Harvard University Press, 1934: 1139b

[3] Including "Art or technical skill, Scientific Knowledge, Prudence, Wisdom, and Intelligence." (Ibid.: 1139b)

[4] Ibid. Bekker page 1140a.

[5] Techné, episteme, phronesis, sophia, and nous are part of a spectrum of reason which can be understood in terms of three qualities: techné, having to do with making/action with intent; episteme and nous, having to do with knowing and intelligence based on rationality; and, phronesis and sophia, having to do with virtue and conduct (ethics). This ecology of techné, knowing, and ethics is what we attempted to articulate in the curation of this book.

One of the most common frames of reference used in contemporary discussions of the concept of techné can be found in Heidegger's essay, *The Question Concerning Technology[6].* Like Aristotle, Heidegger sees techné as a form of discourse and concept making. While *techné is the name not only for the activities and skills of the craftsman*, it is also the name *for the arts of the mind and the fine arts*[7]. As an *arts of the mind,* techné is a key tool in the exploration of knowing (*episteme*), and key in the process of revealing truth:

[6] Heidegger, Martin. "The question concerning technology, and other essays." 1977

[7] Ibid. p. 12-13.

> Techné is a mode of *aletheuein* [getting at truth]. It reveals whatever does not bring itself forth and does not yet lie here before us, whatever can look and turn out now one way and now another. Thus what is decisive in techné does not lie at all in making and manipulating nor in the using of means, but rather in ... revealing[8].

[8] Ibid.

In Heidegger's essay the need for techné is presented with some urgency. In describing our world, Heidegger states that *everywhere we remain unfree and chained to technology, whether we passionately affirm or deny it*[9]. For Heidegger technology has the potential to be out of control, or to benefit humankind. Heidegger does not think we can escape the rise of new technology, therefore in order to make the world a better place we must embrace technology responsibly:

[9] Ibid. p.4

> ...the frenziedness of technology may entrench itself everywhere to such an extent that someday, throughout everything technological, the essence of technology may come to presence in the coming-to-pass of truth.
>
> Because the essence of technology is nothing technological, essential reflection upon technology and decisive confrontation with it must happen in a realm that is, on the one hand, akin to the essence of technology and, on the other, fundamentally different from it.
>
> Such a realm is art. But certainly only if reflection on art, for its part, does not shut its eyes to the constellation of truth after which we are *questioning*[10].

[10] Ibid.

It seems that art is considered particularly ideal for questioning technology because it is something fundamentally different from the frenzied nature of technology. This happens particularly when the artwork is not complacent in the trajectory of technology (speeding towards frenziedness), but confronts that trajectory through questions and a critical discourse grounded in making[11] (*techné*). While Heidegger never directly states it - it doesn't take much of a leap to assert that technology-based art (a form of art that fully embodies the essence of technology) is an ideal tool for questioning technology.

[11] Ibid. p. 35.

In bridging the concept of techné to worldmaking a useful starting point is the Heideggerian concept of *Ge-stell*, or enframing. *Ge-stell* is a term that is used to describe the organization and assemblage of nature. For Heidegger Ge-stell is the mode by which we see the world and how the world becomes known:

> But when we consider the essence of technology, then we experience Enframing as a destining of revealing. In this way we are already sojourning within the open space of destining, a destining that in no way confines us to a stultified compulsion to push on blindly with technology or, what comes to the same thing, to rebel helplessly against it and curse it as the work of the devil. Quite to the contrary, when we once open ourselves expressly to the essence of technology, we find ourselves unexpectedly taken into a freeing claim[12].

[12] Ibid. pp. 25-26

For Heidegger the essence of technology lies in Enframing[13]. Ge-stell is the essential function of modern technology. In the construction of an apparatus, an instrument, or a device, we are enframing the world and helping to reveal it[14]. The questioning of technology therefore lies in how the world is Enframed. Ge-stell is meant to be an active challenge to the world, because enframing is not only a revealing of the world, but a making of the world as well:

[13] Ibid. p. 26

[14] Ibid.

The word *stellen* [to set upon] in the name Ge-stell [Enframing] not only means challenging. At the same time it should preserve the suggestion of another *Stellen* from which it stems, namely, that producing and presenting [Her- und Dar-stellen] which, in the sense of poiesis, lets what presences come forth into unconcealment[15].

[15] Ibid. p. 21.

How does technology Enframe the world? Certainly technology changes the world physically by building roads, growing cities, harvesting energy from the earth, mass farming, and through the entire spectrum of militarization including the polarization of the territories of the earth. But the world is made perceptually as much as it is made physically. New technologies shape what we experience and what we share about our world. As shown in Nelson Goodman's, *Ways of Worldmaking[16]*:

[16] Goodman, Nelson. *Ways of Worldmaking*. Vol. 51. Hackett Publishing, 1978.

...if worlds are as much made as found, so also knowing is as much remaking as reporting. All the processes of worldmaking I have discussed enter into knowing. Perceiving motion, we have seen, often consists in producing it. Discovering laws involves drafting them. Recognizing patterns is very much a matter of inventing and imposing them. Comprehension and creation go on together[17].

[17] Ibid. p.22.

Comprehension as creation parallels the Heideggerian description of *poietic unconcealment*. To make a (different) world is to know (differently). Shifting perception then is the means by which to critique and question the world. We change the frame, change the perspective, and thereby change our understanding of it:

The physical and perceptual world-versions ... are but two of the vast variety in the several sciences, in the arts, in perception, and in daily discourse. Worlds are made by making such versions with words, numerals, pictures, sounds, or other symbols of any kind in any medium; and the comparative study of these versions and visions and of their making is what I call a critique of worldmaking[18].

[18] Ibid. p.94.

Goodman's questioning, or critique lies in *how* worlds are made. According to Goodman worlds are made through processes of eversion that includes *composition and decomposition; weighting; ordering; dele-*

[19] Ibid. pp. 7 - 17

tion and supplementation; and *deformation*[19]. All these processes could be considered a confrontation to the world, and a means whereby to produce alternatives to it.

The domain of worldmaking is that of possibility. When we make worlds, we conject the Other. In doing so we also help shape the world and its trajectory. One of the leading thinkers in the domain of speculative worldmaking is researcher, artist, theorist, and *transarchitect* Marcos Novak. Novak is probably best known for his essay, *Liquid Architectures in Cyberspace*[20] (LAC), a timely and provocative text about the poetics of cyberspace. Among other things, LAC describes a fluidity between the virtual and the real, made possible by the domain of the digital, as extending to all aspects of data, information, and form. This fluidity even includes our minds and bodies as having a potential to be represented in cyberspace as a liquid form[21].

[20] Novak, Marcos, *Liquid Architectures in Cyberspace*, first appearing in "Cyberspace: First Steps." Michael Benedikt. ed. 1991. pp. 225-254.

[21] Ibid. pp. 226-227.

According to Novak, the extreme changes brought forth by technology create unprecedented new opportunities to conceive of new kinds of spaces[22] (or worlds). The characteristics of these spaces transformed conventional modalities of expression from an familiar medium to a new and unfamiliar form, what Novak calls an *extreme intermedium*[23]. The extreme intermedium is *the medium between two media, equally far from both*, [and] *precisely neither one nor the other*[24]:

> Architecture becomes liquid, music becomes navigable, cinema becomes habitable, dance becomes disembodied. As distant as these new options seem from their origins and from each other, they are related to one another by what can only be called 'worldmaking.' Worldmaking is, in my estimation, the key metaphor of the new arts[25].

[22] Novak, Marcos. "Trans-TerraForm: Liquid Architectures and the Loss of Inscription." KR Knowbotic Research (1997). http://www.krcf.org/krcfhome/PRINT/nonlocated/nlonline/nonMarcos.html (last accessed July 13, 2017).

[23] Ibid.

[24] Ibid.

[25] Novak 1997.

We can see the extreme intermedium as questioning the world, as it is a form of enframing, or worldmaking. An important concept related to the *extreme intermedium* is that of *transvergence*[26]. For Novak transvergence is a framework that is used for critical thinking, questioning, rhetoric in general, as well as a methodology in making[27]. Transvergence is an expansion of the *extreme intermedium* into domains beyond the digital, such as *the spaces of nanotechnology and biotechnology and the spaces of consciousness, always considered bidirectionally and on several parallel*

[26] Novak, Marcos. 2002. "Speciation, Transverence, Allogenesis: Notes on the Production of the Alien." *Architectural Design* 72 (Part 3): 64–71.

[27] Ibid. pp. 69-71.

registers: as arts and architectures, as transarchitectures, as formations as yet unnamed, trans~, reflexive, and allo~.[28] These new domains represent potential new forms of knowledge and information that are *alien* to our current understanding of the world. Therefore, Transvergence is a process whereby to predict, and even try to shape future domains.

[28] Ibid. p. 68.

The emergence of new domains is happening at a frenzied, exponential pace. This is evident in the rise of digital technologies and the internet, and is present in newer domains such as nanotechnology, biotechnology, robotics, and artificial intelligence. In this rising tide we are faced with two options: we can wait and see how these domains take shape, then respond; or we can try to anticipate, even *derail* the course of these domains and help create them, thereby creating the world.

The discussion above has left us with many questions regarding the implications of worldmaking as techné in participatory art, music, and architecture. We see worldmaking as having the potential of being an emerging field. However, at the moment there lacks a synergy and common language for it to be so. The book project, therefore, is seen by us as a way to help build a more rounded and formalized language around the concept of worldmaking as techné. We believe that by forming a common language it would be helpful to other theorists and practitioners who work in a similar territory. The book also gives us an opportunity to try and reach a broader community. We wanted to learn about the parallels and the differences between various practices that may fall under the moniker of worldmaking, compare the outcomes in these works, and look for future directions.

A precursor to this book was a panel discussion held at *Inter Society of Electronic Arts* (ISEA) conference in Istanbul in 2011 called, *The Volatility and Stability of Worldmaking as Techné*. From early on we wanted to have a critical approach to this endeavour. The discussion focused on the involvement of the technology of worldmaking in participatory art practice, exploring threads that related to the concepts surrounding worldmaking as techné as found in all areas of technology-based art, such as interactive, generative, prosthetic art, architecture and music practices that depend on the participation of observers for their vitality and development. We invited to the panel discussion, Roy Ascott (electronic arts pioneer and founder of the *Planetary Collegium*), Jerome Decock (member of the art-collective *Lab-AU*) and Marcos Novak (philosopher, pioneer in virtual reality and interactive architecture). The panel's enquiries evolved around:

the aesthetic and historical context for the techné of worldmaking in relation to practice in art technology;
the role of generative and/or cybernetics-inspired approaches (as compared to traditional notions of making) in one's own practice/research;
the implications of worldmaking practice in the real world;
and, the implications of pitfalls and their role in shaping a theoretical and/or practical approach to worldmaking.

The questions led to a lively discussion, which explored the aesthetics, systems, methods, and ontological underpinnings of a worldmaking-based practice. The presentations by the panelists indicated that there was a parallel trajectory that could be understood as worldmaking as techné, but only highlighted the need to find a meeting point for the concepts and language in order to pursue the dialog further. From this impetus the book project launched shortly after, in early 2012. We sought chapter submissions (which were peer-reviewed in a double blind process) and curated reprints to complement the submissions and to round out the discussion. The texts were carefully chosen to highlight the integration of theory and practice in their approach to highlight the continuum of concept to making. Each section contains historical texts alongside new texts to show a line of thought that spans more than 60 years, as well as to provide a historical foundation to the discourse.

Structurally, the book is organized into three sections: *po(i)etic*, *machinic*, and *cybernetic*. The intent in creating sections in this book was not an attempt isolate the discourse between the works, rather we see them as plateaus in a rhizome of concepts that intersect each other fluidly. In selecting works to fill these sections, we sought to break the frame at the same time we built it by choosing unconventional texts by familiar authors, and by including texts in sections that fall outside of their normal categorization.

Po(i)etic

The title for the first section of this book is a portmanteau between the terms *poiesis* and *poetry*. *Poiesis is an* ancient Greek term (ποιέω) meaning to bring into existence something which did not exist before[29]. There are two forms of poiesis: autopoiesis (self-creation) and allopoiesis (the creation of the other), which work in tandem to as a meta-description of the processes of nature, readily encapsulating systems of evolution, homeostasis, emergence, and similar processes that are the foundation of the living world. Fundamentally the defining of poiesis is an attempt to define how living things come into being through the organization of nature as a system. If one can understand the system, then one can understand the workings of nature itself.

[29] https://en.wikipedia.org/wiki/Poiesis

Poetry, which means making, is derived from poiesis[30]. Poetry is traditionally considered a literary form, but if we look closely at its etymological origins it becomes clear that poetry has deeper implications of any kind of making, especially any human made work that brings forth aesthetic results. Aristotle's Poetics, for example, was not just a treatise on literature, but a treatise on the theory of art and making in general, focusing in particular on themes of catharsis, and the social and ethical utility of art[31].

[30] Ibid.

[31] Halliwell, Stephen. *Aristotle's poetics*. University of Chicago Press, 1986.

The po(i)etic is the domain of techné, representing the aesthetics and methods of *what* kinds of worlds we are making, as well as *why* we make them. The bringing together of these two related terms is meant to describe the drive to make living artworks. These works are poietic (unexpected/emergent), but are shaped by the artist (poetic) in order to express a particular idea, or experience that is either a reflection of the known world (autopo(i)etically), or a view into one that is alien and unfamiliar (allopo(i)etically). The balancing of these concepts is foundational in the aesthetics of worldmaking and computational art. Therefore, the po(i)etic and making is highlighted in this section as examples of how the poiesis and poetry come together in various practices in the production of work.

This section begins with the work of Nicolas Schöffer (1912-1992), a pioneer in the domains of cybernetic, robotic, and computational arts. Written late in Schöffer's career, *Sonic and Visual Structures: Theory and*

Experiment (1985) provides a succinct and compelling overview of the motivations and organization of his work, and the framework in which he works through his experimentations in sound and music. Schöffer's practice in what he called cybernetic art began in 1948 and focussed on several themes, including *spatiodynamisme* (1948-1958), *luminodynamisme* (1956-1977), and *chronodynamisme* (1959, on). While his works are often primarily considered kinetic sculptures, his primary focus as an artist was on engaging the senses, including space, light, time, and, new at the writing of his text, sound. The scale of Schöffer's work extended from the object to architectural, and even urban scale. His work often contained motors, sensors, and responded to the world around them using cybernetic principles as a basis for behaviour. He was deeply motivated by the role of art and aesthetics in everyday life and sought to engage humans interactively in the experience of his work, what he called, *activated humans*. Schöffer's aesthetic and methodical contribution is a highly adaptable system of thinking that deeply considers the impact that art has on the world.

In the second article, *Inventing Causalities and Networks of Influence*, Alberto de Campo explores a key notion in worldmaking: Creating mechanisms by which artificial worlds function is inventing causalities, and their possibilities for diverging from conventional cause-and-effect are essential artistic choices that deeply influence the experience of these worlds. A tour of common and unusual notions of causality, its limits, and skepticism toward it touches a multitude of historical and current perspectives, including philosophy, sociology, psychology, and behavioral economics, concluding with circular causality as postulated by cybernetics, and radical constructivism. To show the applicability of these conceptual perspectives for both analysis and creation, de Campo discusses a number of his own works and the works they relate to. Finally, the concepts underlying his current approach for improvising music with nontrivial processes directly forgo linear causality, in effect giving up causal control in favor of networks of influence which can only be understood intuitively through the experience of playing with them.

[32] http://ciat-lonbarde.net/plumbutter/

A reprint from his blog[32], the intent in formatting Peter Blasser's, *An Essay on Worldmaking in Plumbutter* was to remain as true to the original style of writing as much as possible. On first impression, Blasser's text is a description of a drum machine, but it is so much more. The poetic and reflective narrative provides an inside look into the inner workings of his artistic approach and process. In an unrelenting fashion, Blasser's text embodies the spirit of the work by guiding you through a psycho-geographical exploration of *Plumbutter* that is at once tangible and surreal. Told from the perspective of *Plumbutter,* the text describes the development process of creating a drum machine developed as a result of a convergence of technical and philosophical considerations that equally feed into the details of the layout and design of the unit. *Plumbutter* is the embodiment of techné. Within the text one gains the sense that within his development of this multidimensional instrument no aspect is left to chance, no possibility unconsidered, and its creation is deeply personal and meaningful.

The survey of work that artist James Coupe provides in his text *Art, Surveillance and Metadata* reveals the potential of worldmaking as a critical discourse. One of the fascinating things about working with technology as a medium means that, as a critical discourse, *artists can make work that uses the same tools deployed by governments – not painting pictures of these scenarios but operating in the same reality, with the same methods recast*[33]. In Coupe's case he uses metadata. Metadata is a set of information that provides a descriptor of other data that is too large to analyze quickly[34]. Metadata is stored with the data and is usually hidden during normal viewing. The use of metadata is quite useful in summarizing otherwise unmanageably large data sets, but ethical issues arise when the data is used to summarize us. Coupe's work provides an exploration of the potential uses of an otherwise unseen metadata to identify and categorize us, and exposes it to the audience. He constructs generative narratives using the audience's metadata, exposing how we are in profiled by various entities in the process. This includes voluntary services like Facebook and Twitter, as well as in surveillance programs, such as with the National Security Agency (NSA) of the United States. The result is a chilling look at a the dystopian reality of our own world and the pervasive cataloging and surveillance we are subjected to on a daily basis, exposing the world as it is in order to shape what it could be.

[33] Coupe, p. 88.

[34] For images this might include the *image's size, resolution, and date of creation; for an audio file, it might include the file format, the author, title, etc.* Coupe, p. 69.

Dan Overholt and Esben Bala Skouboe's *Perceptual Ecologies: Mine* discusses the technical and conceptual implementation of the *Perceptual Ecologies* art installation in the Thingbæk Kalkmine, an abandoned limestone mine near Aalborg, Denmark. A multidisciplinary work between programmers, engineers, musicians and architects, *Perceptual Ecologies* shows how technology can be used to create novel experiences of alternate worlds as art. Motivated by the creation of affect, Overholt and Skouboe use *the term atmosphere as an abstract machine with which to establish a common ground, uniting the disciplines of music and architecture into a world of 'living' perceptual compositions*[35]. With this in mind Overholt and Skouboe use an expanded notion of ecology to produce an environment of cybernetic social interaction between observers and the physical work, the virtual work, and each other. In the spirit of experimentation, *Perceptual Ecologies* provides a glimpse into the challenges and considerations of producing large-scale immersive environments as interactive worlds.

[35] Overholt Skouboe, p. 91

In *Towards Probabilistic Worldmaking: Xenakis, n-Polytope and the Cybernetic Path to Chaos*, Chris Salter and Sofian Audry provide a detailed discussion of their work, *n-Polytope. n-Polytope* uses a series of works by architect and composer Iannis Xenakis (1922-2001) known as the *Polytopes* as a point of departure[36]. Created between 1967 and 1979, the Polytopes were remarkable, forward thinking immersive light, sound and architectural installations that influenced and anticipated computational art thinking today. As described by the authors *n-Polytope is based on the attempt to both re-imagine Xenakis' work in probabilistic/stochastic systems for composition with new techniques as well as to explore how these techniques can exemplify our own historical moment of extreme instability*[37]. Through this endeavour the artists not only help to share the influence Xenakis had on contemporary art and music, but discover new methods and approaches to making art today. These include aesthetics and techniques in art-science and worldmaking with the goal of generating new *artistic forms or morphologies*, and through new forms of knowing.

[36] Salter and Audry, pp. 115-116

[37] Ibid. p. 116.

Machinic

This section explores notions of the machinic through the discourse of practitioners who use abstract assemblages and frameworks to describe and implement their work. We derived the term *machinic* from the first chapter in this section, *Machinic Heterogenesis,* by renowned philosopher Felix Guattari (1930-1992). In the simplest terms the machinic describes the relationship between human and machine. The machinic resides in the same rhetorical space as techné, but where techné focuses on *why* the machinic emphasizes *how*. As Guattari noted, for Aristotle the goal of techné is *to create what nature finds it impossible to achieve, so that techné sets itself up between nature and humanity as a creative mediation.*[38] Guattari's description also includes notions of the machinic that go beyond creative mediation. For example, there is the inclusion of the world of living beings, which have similar qualities to machines (or are even considered machines in their own right) but without an anthropocentric purpose (or any "purpose" at all). Guattari also includes the Heideggerian notion that *entrusts techné, in its opposition to modern technicity, with the mission of "unveiling the truth*[39]*,"* as was discussed above. When we look at the systems that make up our world there are many processes beyond the technical that can be described as machines. Among these possibilities Guattari includes the technical, social, semiotic, and axiological, making up what he refers to as a *machinic ordering*[40].

[38] Guattari, Felix, *Machinic Heterogenesis,* p.145

[39] Ibid.

[40] Ibid. p.146.

Machinic Heterogenesis provides a description of the high-level processes that govern a machine and its modality of production. There are two aspects to the machinic: the diagrammatic and the materialized machine. The diagrammatic machine exists virtually, as a *protomachine*[41]. The materialized machine exists as an instance of the diagrammatic. The diagrammatic is capable of producing many materialized machines and, unlike the materialized machine, is unfixed and always in flux.

[41] Ibid. p.146.

While not cited directly in Guattari's text, the domain of the computational is an exemplar of the machinic. Computational processes are not limited to digital computation and can include mathematical, biological, and other systems as their basis. What is unique in the digital domain is that the diagrammatic computational system (model) and the materialized result of that system (instance), are created using the same tools. As a result the machinic processes of abstraction and implementation are often blurred. For instance the materialized form of the computational machine has the ability to evolve, *dematerialize*, and produce other machines *auto-* and *allo-poietically*. The diagrammatic can even produce materialized machines that recursively rewrite the diagram and re-instantiate themselves as they run.

Computational methodologies are key in artist Mark-David Hosale's description of the conceptual framework, the *Worldmaker Universe*. Hosale's framework is based on an epistemological model that includes a representation of both perceivable (known) and imperceivable (unknown) aspects of our world. The framework is separated into three parts: operations (all information before it is perceived and the imperceivable), transforms (the interpretation of perceivable information into our sensorium), and personae (the perception/experience of that information). While primarily conceptual, the framework is used to create software and hardware tools that result in concrete implementations of computational artworks. The framework is also used in the description and analysis of existing works, as a theoretical tool. There is perhaps a paradox in Hosale's approach in developing a framework that is used in production of software and hardware applications that are primarily quantitative; and adapting it for the analysis of work, a domain that is primarily qualitative. However, the ability of his framework to be used bi-directionally in the creation and analysis of work facilitates a feedback loop between concept, making, and reflection that is highly adaptable to various kinds of work.

As an exploration of *Techné and Dispositif of Architecture*, Sang Lee looks at the role of architecture as a dispositif in the face of new technologies. Commonly translated in to apparatus[42], the dispositif draws parallels to concepts in the machinic. For example, there is a synonymous relationship between what Guattari describes as the *diagrammatic* and the *material* with what Lee refers to as *codification* and the *apparatus*. According to Lee, architectural practice is one of codification, in that the role of the architect is to produce the schemata that describe in great detail what is to be built, but are disconnected from the building process itself. In contrast, digital architecture has given rise to a *new rationality*, facilitated by generative and parametric processes that allow for a *dynamic disposi-*

[42] Lee, Sang *Techné and Dispositif of Architecture*, p. 196

tif. One example of this is the trend towards the development of what is known as *biomimetic* architecture. *Biomimetic* architecture proposes to create buildings that are analogous to a biological organism in its organization and function. For Lee these trends represent a potential benefit or a detriment to humankind, depending on the approach of the designer. In architecture, where aesthetics often take precedence, Lee offers a biting argument for the need to create a better balance with utility in this new domain: *The substance of our relationship to natural organisms and environments is at stake, not the usefulness or affectation of such technological organs installed in order to satisfy our excesses and to reinforce our dysfunctional so-called lifestyle*[43].

[43] Ibid. p. 215.

Laura Beloff's *Experiencing the World: Wearable Technology and the Umwelt* is a compelling survey of a series of her works and how they have evolved since the mid-2000's. As suggested in the title, the point of departure in Laura Beloff's work is Jakob von Uexküll's concept of the *Umwelt*. Beloff uses wearable technology to explore how we can alter our Umwelt through the augmentation of the body using wearable devices. The goal in Beloff's work is to explore how a human can connect to a wearable augmentation that is affected by elements humans are normally not aware of, such as the technological umwelt, the umwelt of other organisms, and the processes of the environment. According to Beloff *the world is full of interconnecting and overlapping spheres— like a conglomeration of bubbles forming multiple perspectives in which each organism has its own umwelt*[44]. The joining of these umwelten creates what she calls *a techno-organic constellation*[45]. By following the trends of contemporary technology, she suggests that this kind of modification is becoming a necessity as we may need to enhance our bodies in order to be able to survive our changing techno-scientific relationship to the world. The result is a condition where humans are not just mediated by machines, humans become the machines themselves.

[44] Beloff, Laura, *Experiencing the World: Wearable Technology and the Umwelt*, p. 220.

[45] Ibid.

We conclude this section with Graham Wakefield's *Open Worlds: Bergson And Computational Ontology*. Wakefield's chapter provides a thought provoking discussion on computational aesthetics and world-making that attempts to address the challenge of making worlds *that approach the open-endedness of the natural reality we inhabit*[46]. As

[46] Wakefield, Graham, *Open Worlds: Bergson And Computational Ontology*, p. 243

Wakefield identifies a tendency in computational creativity to rely on static models of nature that are too deterministic, and based on the *world-as-we-know-it.* In Wakefield's view, the reason for this tendency towards determinism is not because of any limitation of computation, or of programming languages themselves. Determinism is more symptomatic of *our natural habit to abstract discrete static snapshots of continuously flowing reality through the selective actions of perception*[47]. To counter this tendency Wakefield turns to Bergsonism, in particular concepts, such as the *durée*, that emphasize *a conception of reality as a whole that is continuous and creative, predicated not on a static notion of being, but rather on an enduring notion of becoming*[48]. The remaining chapter gives an intriguing description of how computational systems can be developed that are free of linguistic constraints, self-executing, and evolving, which he describes as a *strongly constructive inhomogeneity*[49].

[47] Ibid. p. 248.

[48] Ibid. p. 249.

[49] Ibid. p 257.

Wakefield's use of the term inhomogeneous is interesting as it is synonymous with heterogenesis, which brings us full circle to Guattari's text. In the end, Guattari's concern with the machinic has *nothing to do with their materiality*, but within the diagrammatic processes whereby machines evolve over scale, form, and time[50]. The relationship between the materialized and the diagrammatic is analogous to that of the genotype and the phenotype in biology. The diagrammatic is like the genotype (high-level evolving form of the machine)[51], and the materialized the phenotype (an individualized form of the machine). Heterogenesis in Guatarri's machinic therefore exists in the diagrammatic form describing how machines produce other machines that are of a different kind than themselves (allopoiesis). What is important here is to consider how the machinic can lead to worldmaking. If we want to make meaningful worlds then we need to consider how to make worlds that are open-ended and, as Wakefield describes, *more inherently creative.*

[50] Guatarri. p.151. and throughout.

[51] For Guatarri the diagrammatic form of the machine exists at the *phylum* level, which could be understood a genotype by interpretation.

Cybernetic

Cybernetics is a meta-discipline that aims to describe and understand systems and processes from very different domains with the same set of fundamental concepts. It was constituted as a field in the Macy conferences organized by Warren McCulloch from 1946 to 1953, who invited the leading scientists of the times from fields like anthropology, mathematics, neurology, psychiatry, biophysics and others. The term *circular causality* in biological and technical systems refers to phenomena that occur when parts of a system influence each other such that linear causal chains form loops, requiring the new concept of feedback. At the time, this idea was in the air in many fields. The name cybernetics was adopted from the eponymous book by Norbert Wiener, when Heinz von Foerster proposed it as the ideal name for the conference series, and it later became the common label for this meta-discipline.

In the first phase of cybernetics (later called first order cybernetics), one assumed that observers can study the causal pathways in systems from the outside, deduce how to influence the system in question, and then control it such that it reaches the desired state. Typical states are stable dynamic balance (homeostasis), cyclic balance (periodic oscillation), and aperiodic behaviour (chaos). This concept was quickly adopted by military, political and economic leadership, as it seemed to promise technocratic control of societies worldwide.

Second order cybernetics (or cybernetics of cybernetics, as Margaret Mead put it) emerged from 1965 on, and here cyberneticians consider the observer an essential part of the system who always influences the system from the inside. This view foregoes classical notions of scientific objectivity (which were criticized from other perspectives at the time as well, e.g. as constructions of power and control), and replaces it with the now common-sense idea that one understands a system much better by interacting with it, and thus encountering its behavioural repertoire actively.

Both waves of cybernetics were adopted quickly in many disciplines, and over time got absorbed into the invisibility of standard practice in each field. After a phase of buzzword fatigue, its history has been studied more deeply again since the 1990s by the Heinz von Förster archive in Vienna, in particular by Albert Müller and Karl Müller, and Andrew Pickering. Andrew Pickering, the author of the first selection in this section[52], is a historian of science and a pre-eminent scholar responsible for the rediscovery of the early British cyberneticians, and reinterpreting their complex worldview, which was the subject of his influential book, *The Cybernetic Brain*[53].

[52] See pp. 266-295.

[53] Pickering, Andrew. *The cybernetic brain: Sketches of another future*. University of Chicago Press, 2010.

One of the early advocates and educators of second order cybernetics in the field of interactive arts is media pioneer Roy Ascott. His artwork *Change-Paintings* first exhibited in Molton Gallery in London in 1961 was one of the early pieces of art that demonstrated the need for participatory interaction from the audience for what is ultimately an open-ended piece of work.[54] Ascott's focus on creativity of art practice as a process of becoming influenced by making and participation had shaped his future theoretical and art work. He laid out the foundations for examining the concept of art as a behavioural problem in his 1963 text *The Construction of Change*.[55] For Ascott, behavioural art production and art education were inseparable. Following on from *The Groundcourse* pedagogic framework devised in 1963 for his students in Ealing School of Art in London, and Ipswich School of Art, which embraced a syncretic approach to creativity that combined in its making analogue and digital elements and systems, Ascott operated among other British cyberneticists on the shift in focus from the brain and into performative art forms where the spectators interacted in a system of control and communication through the construction of structures in physical and cyberspace. He introduced theoretical concepts such as *Moistmedia* and *Telematic Art*. In 2003 he defines networking in the arts to be "a shared activity of mind and a form of behaviour that is both a dance and an embrace."[56] He opposes the need for the centrality of the existence of the body in the system of perception going on to suggest that networking takes the physicality of the body out of the system by linking the mind to a kind of timeless sea[57] and by doing so, the focus moves onto the transformation of the artwork, or as Ascott calls it, *creative data*, which appears in a constant process of becoming and perceptual motion:

> In this sense, art itself becomes, not a discrete set of entities, but rather a web of relationships between ideas and images in constant flux, to which no single authorship is attributable, and whose meanings depend on the active participation of whoever enters the network. In a sense, there is one wholeness, the flow of the network in which every idea is a part of every other idea, in which every participant reflects every other participant in the whole... The observer of the 'artwork' is a participator who, in accessing the system, transforms it.[58]

[54] Ascott, Roy, (1961) *Change-paintings* [Online]. London: Facebook. Available: http://www.facebook.com/album.php?aid=18986&id=554994561&l=2bd59f766d

[55] Ascott, Roy ,([1964], 2003) 'The Construction of Change' (1964), in *The New Media Reader*, ed. by Noah Wardrip-Fruin and Nick Montfort (Cambridge, Mass.: MIT Press, 2003), pp. 128-132.

[56] Ascott, Roy, (2003) *Telematic Embrace: Visionary Theories of Art, Technology and Consciousness*, Berkeley, CA: University of California Press. p. 200.

[57] Ibid, p.187.

[58] Ibid, p.199.

The *Cybernetic* section explores the world as a system (as manifested in First Order Cybernetics) and leaps into the new cybernetics of participatory environments where systems are in fact actor, agent, and observer dependent (as seen in Second Order Cybernetics). This connection is based on a feedback loop, where the participant and the environment are just as much a part of the system as the algorithm (and interface to the algorithm) itself. As with the machinic cybernetic systems can be seen as having diagrammatic and the materialized forms. Because of this cybernetics could be seen as a branch of the machinic[59]. One of the key differences between cybernetics and other machinic systems is one of approach. While other systems tend to approach the *question of technology* by seeking to shape the frame, re-enframing the world, cybernetics attempts to change the manner in which we associate with technology altogether by engaging the processes of nature as part of a system.

[59] Guattari considered the cybernetic as fit for his description of the machinic. see Guattari, p. 144.

In *Beyond Design: Cybernetics, Biological Computers and Hylozoism*, the selection for this volume, Andrew Pickering focuses on the work of Gordon Pask and Stafford Beer in the field of biological computing. The presentation of this history is used to a show how cybernetics can be used as a means of questioning technology. Pickering posits the importance of the distinction between two different paradigms in the history of science and technology: *Modern* and *nonModern*. While Modernity aims at the eventual domination and consumption of nature, the cybernetics of Pask and Beer represents a *nonModern* approach which embraces the processes of nature to achieve its goals. For example, Pask and Beer's approach to biological computing is to treat biological units as black boxes with performative elements, catalyzing their actions for use as computational machines without really knowing *how* they work. By contrast, the Modern technoscientific approach is to attempt to unwrap these boxes, and mimic and redefine their inter-workings in order to build cognitive machines from the bottom up. In short, Pask and Beer's attempt to work with nature, rather than redesign or control it. While the major examples provided in the article are biological, Pickering describes how concepts in cybernetic computing are applicable in any natural system. Hence the use of the term *hylozoism*, an ancient Greek word that described the belief that all matter has life, and therefore is able to function as an actor in a human created cybernetic system. But in order to achieve this kind of collaboration with nature we need a major shift in our thinking. What Pickering is arguing for is a paradigm shift in our worldview that moves away from the destructive path of Modernism to a paradigm of collaboration with nature. As Pickering states: *...if Modernity is defined by projects of domination, then cybernetics is marked by a symmetric accommodation to the ultimately uncontrollable*[60]. In Pickering's view, the ability to give in to the uncontrollable quality of nature would lead to a holistic connection to our world. The implications of this paradigm shift would not only be present in our technology, but in our social interactions, our political systems, and in our minds as well.

[60] Pickering, Andrew, *Beyond Design: Cybernetics, Biological Computers and Hylozoism*, p. 294.

Sana Murrani picks up the influence of the social dimension of cybernetics and how it relates to worldmaking in an attempt to re-evaluate, re-interpret and re-appropriate space through a spatial and technological installation that culminates in a triadic enquiry into the ontological, ontogenic and behavioral conditions that govern a world. Her work focuses on Goodman's notion of irrealism and Leibniz's relational theory, and their impact on the way we perceive and conceive the construct of space and place. Murrani develops a hypothesis that advocates for a bottom-up relationship between the designer/architect and their work which facilities for the users, participants and inhabitants to occupy, re-appropriate, re-assemble, and re-make their environments. Through critical analysis of the construction and re-constitution of a spatial-technological installation: *Overlaid Realities*, Murrani's chapter puts forward a participatory architectural praxis that is based on principles of second-order cybernetics and post-phenomenology through cognition and indirect perception, network society and the contingent nature of participation in space/place.

World-renowned artist and architect Philip Beesley's *Sentient Canopy: Prototype for resilient, curious architecture* provides a deep insight into the conceptual motivations and technical implementation of his work. In this text, Beesley provides a detailed description of the layers of systems that contribute to the creation of *Sentient Canopy* and how they are developed. Technical considerations are infused with conceptual considerations that embody questions about how architecture can become a living system, what the implications of creating such systems might be, and how the role of architecture could be shifted to create better connections between our environment and each other. Resilience in his work is therefore not limited to material resilience, but in terms of architecture's function as well. Beesley's approach to thinking and making architectural systems goes beyond Vitruvian utility by also considering the role of agency and experience in the foundation of its development. For Beesley, his work seeks to challenge the control and the lack of empathy of typical interactive systems, by creating a near-living system as a responsive architectural environment that is inspired by natural processes.

Kathrine Elizabeth Johansson uses an analysis of Philip Beesley's *Hylozoic Series* as an exemplar of how technology-based arts can create worlds that have a profound impact on the way we understand consciousness and reality. Johansson offers a sophisticated discourse around art communication and philosophical speculation that presents a real challenge to the ways to approach knowledge and making. As indicated in the title, *On the dynamic relation between thought ontologies and materialised ontologies*, Johansson's text contemplates *how* and *when* the materialized form of an artwork is able to communicate ontological propositions that are free from rhetorical constraints, and primarily experiential. She describes the difference between acquired and experienced knowledge as a mind-altering encounter, and how the latter, which is influenced by the work seen in the design field of near-living systems and environments such as Beesley's *Hylozoic Series*, has a profound impact on the way we understand consciousness and life. The making of experiential ontologies requires the activation of different levels of reality such as the Artefactually Real (human-made material realities), the Socially Real (systems and mechanisms at the social level), and the Virtually Real (any aspect of Nature that must be understood to be intangible). It is through the domain of the Artefactually Real that we can connect (re-acquaint) ourselves to the other levels of reality and stimulate sub-conscious forms of knowing. Therefore, Johansson believes that a well-considered techné requires a deep consideration of the Artefactually Real to *ontologically re-acquaint ourselves and our common significations and interpretations of the Nature*[61] (such as with Beesley's work) in order to engage a practice of worldmaking that can meaningfully affect the process of creativity in constituting knowledge.

[61] Johansson, Kathrine Elizabeth, *On the dynamic relation between thought ontologies and materialised ontologies*, p. 359.

Edward Shanken's text, *Towards a Genealogy and Futurology of Art and Technology: New Media, Contemporary Art, Collaboration* provides a thoughtful discussion of the challenges that face practitioners and curators in the field of art, science and technology (AST). This is supported by a compelling historical account of the foundations of art and technology including an analysis of the motivations behind the AST collaboration Experiments and Art and Technology (E.A.T.), which included, among other artists, Billy Klüver, John Cage, and Robert Rauschenberg. Through this description, Shanken reminds us that such collaborations are risky; nevertheless, they bear significant potential of reaching truly surprising new insights and ideas into the conception and construction of knowledge and society. Shanken also describes how New Media Art (NMA) has struggled to distinguish itself from mainstream contemporary art in terms of its role in the art world, motivations for making, and in finding acceptance. This is largely because NMA sits between art, engineering, and mainstream media but has trouble gaining acceptance in any of these domains. Finally, Shanken calls for work in AST to be bold and take risks in producing meaningful work that will generate breakthroughs in art and technology. AST research must develop *compelling rationales for the importance of their work as an engine for innovation*[62] in order to gain the acceptance and support it needs to continue.

[62] Shanken, Edward, *Towards a Genealogy and Futurology of Art and Technology: New Media, Contemporary Art, Collaboration*, p. 383.

For the final selection of this chapter and the book, we chose a seminal text that looks forward to the future and thinking of what worldmaking could be. For those familiar with Heinz von Foerster's (1911-2002) life and work, *Perception of the Future and the Future of Perception* is not a surprising text. The originator of second-order cybernetics, von Foerster is a polymath whose impressive range of work spanned the domains of philosophy, physics, cognitive science, computer science, and mathematics. The philosophical focus in his research is particularly present in the later half of his life, when there is a gradual shift from a technical focus to issues of aesthetics, ethics, and epistemology. One could easily argue, however, that there was really not much difference in his mind between the two eras. For von Foerster second-order cybernetics functioned as a metaphysics that glued the world together, whether addressing problems in hard or social sciences.

Written in 1972, *Perception of the Future and the Future of Perception* comes at a time, like today, when there was much turmoil in the world. The urgency in tone of this text is marked by the aftermath of a turbulent 1960's, a war in Vietnam, and an ongoing Cold War, which left the world uncertain about its future. One way to interpret this text is as a description of how to make a better future world, and for von Foerster the future of the world is dependent on our perception. Therefore von Foerster provides a guide for *how* to perceive the world, stating boldly:

> if we can't perceive,
> we can't perceive of the future
> and thus, we don't know how to act now[63].

[63] von Foerster, Heinz, *Perception of the Future and the Future of Perception*, p. 386.

He does this through the reevaluation of language, for how we use language tells about what we prioritize in our world. The text turns into a manifesto by encouraging us to question, play, and do our irreverent thinking in order to resist modes of discourse that keep us within conventional limitations. His text is as relevant today as it was when he wrote it. After all we live in an era of great divisions driven by unwavering ideologies and alternate-facts, we can see the power of words to *enframe* the world, and even to create bubbles (Umwelten) that are seemingly impenetrable, as rationally untenable as they may be. It is not a leap to say that, if we had the rhetorical tools to properly evaluate our world, then perhaps we could start to find ways out of the difficulties that plague us today.

Our ambitious goal in this volume is to attempt to outline practices that challenge the World and its possibilities through a kind of future-making, and/or other-world making. But most importantly, what we strive to create in our work are alternate realities that are simultaneously ontological propositions that can be understood through experience, as much as through language. We see our works as the expression of ontological propositions enframing the world through the creation of art-worlds. By exploring art as techné we create experiential concepts that enframe the World we live in. In doing so we offer a critical discourse about our World and how the World is constructed.

By positioning worldmaking as a kind of techné, we seek to position worldmaking as an enframing of the world by exploring art-concepts through the development of art-worlds. Therefore, worldmaking can be understood as an expressive practice, one that is enacted through arts, as a techné.

While the foundation of this worldmaking is deeply philosophical and rigorous in its approach, there is a need to connect this work to the World of our everyday experience. As we contemplate issues of why we might want to make a world, we are confronted with the responsibilities of making the World as well. There is an ethical urgency in the world today to change from a path of mutually assured destruction to one that leads to viability. In this context, we see the future of a worldmaking based practice as an opportunity to explore the World as it is, and the myriads of ways how it could also be, to make the World a better place for now and for future generations.

– Mark-David Hosale, Sana Murrani, and Alberto de Campo.

Po(i)etic

Sonic and Visual Structures: Theory and Experiment

From: Leonardo, Vol. 18, No. 2 (1985),
pp. 59–68, The MIT Press

Nicolas Schöffer

I. REFLECTIONS ON MUSIC AND SOCIETY

Like a space empty of any visually perceptible content, an environment totally silent, without any sonority, is difficult to conceive and would not be bearable. Sonic information, like visual information, feeds us even if it assaults us.

Sonic information – which is my concern in this article – comes from natural and artificial sources. Natural sources, those caused without the direct intervention of humankind, come from the elemental world (such as a murmuring wind or deafening thunder), the plant world (such as cracking and falling sounds), and the animal world (such as the rubbing of the elytrons [wing-shells] of insects or the trumpeting of elephants), or the interaction of these worlds. Artificial sonic information comes from a wide range of sources, from speech to the noise of tools, from song to polyphonic instrumental music, and extending to artificially created sounds.

Music is an improvised or pre-organized alternation of isolated or grouped sounds and silence, within certain time limits. A more or less aesthetic and meaningful content can be ascribed to these alternating sounds and silence according to their original source and their destination. Music's final value is determined both by environmental factors and by history [1, 11].

This definition of music specifies its limits in relation both to time and to its insertion in the sociocultural context whose characteristics are changing with extreme rapidity.

Historic Limitations of Music

The limited time it takes music to unfold, which always comprises a beginning and an end – even when improvised – places music in a situation different from that of traditional visual works. The latter, with the exception of works using cinematic techniques and certain video experiments, exist in time without their duration being defined or limited either at the level of their conception or at the level of their perception. On the spatial plane – although this is not a constant – the size of visual works can entail a limitation comparable to the temporal limitation of music.

[1] To avoid misunderstanding, I have given new or more elaborate definitions to various commonly used terms such as man, consciousness, culture, art, cybernetics, economy, politics, power, information, perturbation, etc. Musical creation being art, my fundamental definition of art is as follows:

"Art is the creation-invention, on the level of the mechanisms of thought and imagination, of an original idea having an aesthetic content that can be translated into effects perceptible to human senses. The occurrence and the ordering of these effects are worked out by a program in time or in space, or in both simultaneously, their components and their proportional relations being optimal, novel and aesthetic.

"These effects are transmitted through visual, auditory or audiovisual signals to those who, accidentally or deliberately, become spectator-auditors of these effects.

"The result is a process of fascination giving rise to a more or less profound modification of their psychological fields depending upon the aesthetic value of the creation.

"This modification must be in the direction of transcendency, sublimation and spiritual enrichment through the complex mechanism of the human sensibility and intellect.

"Thus, thanks to the creator's overreaching faculty, aesthetic products having a strong impact penetrate through the multiple communication networks to social reality.

In order to achieve this end, the creator must use a language and techniques which correspond to the true level of development of his time."

It is evident that music is more limited in time than the visual arts. The visual arts can be very limited in space – easel painting is an example – or they can go beyond their traditional spatial limits and beyond the spatial limits of music, as seen with sculpture (Eiffel Tower) and architecture (Rockefeller Center). We can thus consider music to be more handicapped in its freedom of expansion and conception than the visual arts, even if contemporary technology enlarges its spatial field of action. Its percussive quality, however, its capacity to 'densify' sonic effects within a limited space-time framework and to induce concentration, gives it an increased power on the level of perception-reception.

The real challenge in artistic research is to attain a maximum of freedom, freedom to define and select parameters for a combinative formula designed to enrich the quality and quantity of the effects produced. By developing ideas without redundancy and by allowing acute as well as unforeseen impressions to arise, one can thus explode the temporal and spatial limits of the work. In order to accomplish this in music, one must eliminate one of its essential characteristics: its very confinement within temporal and even spatial limits.

But music without beginning or end is no longer 'music', it is already something else. On the sociocultural level, time limitations lead to limitations on the consuming of music – that is, its availability[2]. On the sociotechnical level, music has been consumed in limited spaces and times. These limitations have censored its creators. Musical composition has been founded on extremely rigid rules, where defined time has been programmed from relationships clearly signifying the linearity and ordered arrangement of its unfolding. Thus, music made linear and enclosed within its temporal prison has been the dominant form up to the present.

How does one move beyond this? The solution is in my opinion simple: one need only transfer the techniques of visual arts to the techniques of sonic arts and rethink the problems of technical and social diffusion and consumption of music.

However, it is not enough to create a work. This work must insert itself in the programs which guide the unfolding of individual and collective existence. The problem is both technical and conceptual[3]. The specifically programmed time of the work must intervene, participate and

[2] Music being linear, listening to it implies concentration and therefore limitation of its consumption in time. On the contrary, with a sculpture or a painting, this linearity of time disappears.

[3] N. Schöffer, *La Ville Cybernétique* (Paris: Tchou Ed., 1969 and Paris: Denoël/Gonthier, Bibl. Mediation, No. 91, 1972). This fundamental book and a few others of the ten I have written have been translated into Italian, Japanese and Spanish but never into English.

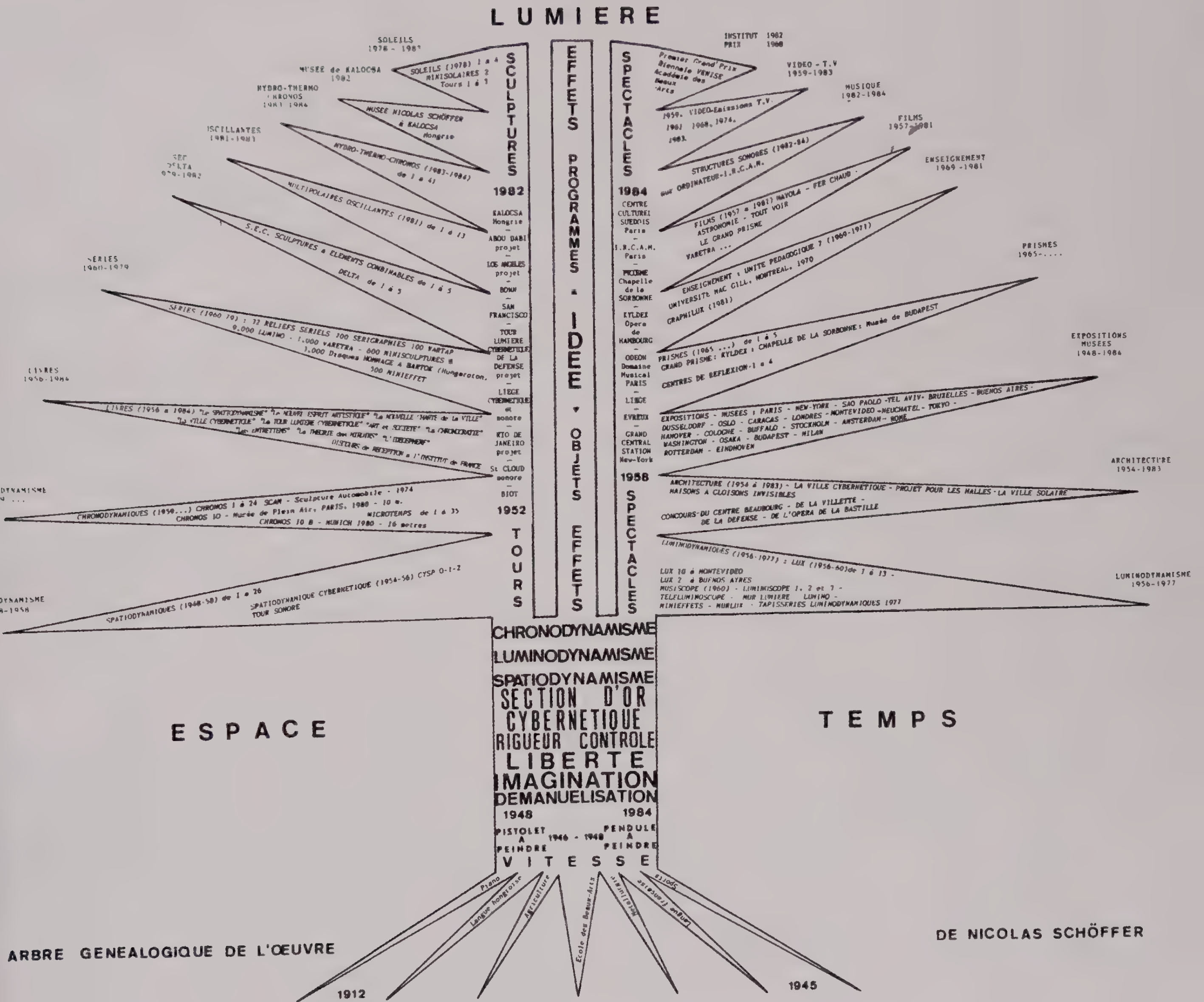

Figure 1. *Genealogical Tree of Nicolas Schöffer's works*, 1984. This scheme sums up the author's work in various fields of activity, illustrating in a coherent way the usual curriculum vitae.

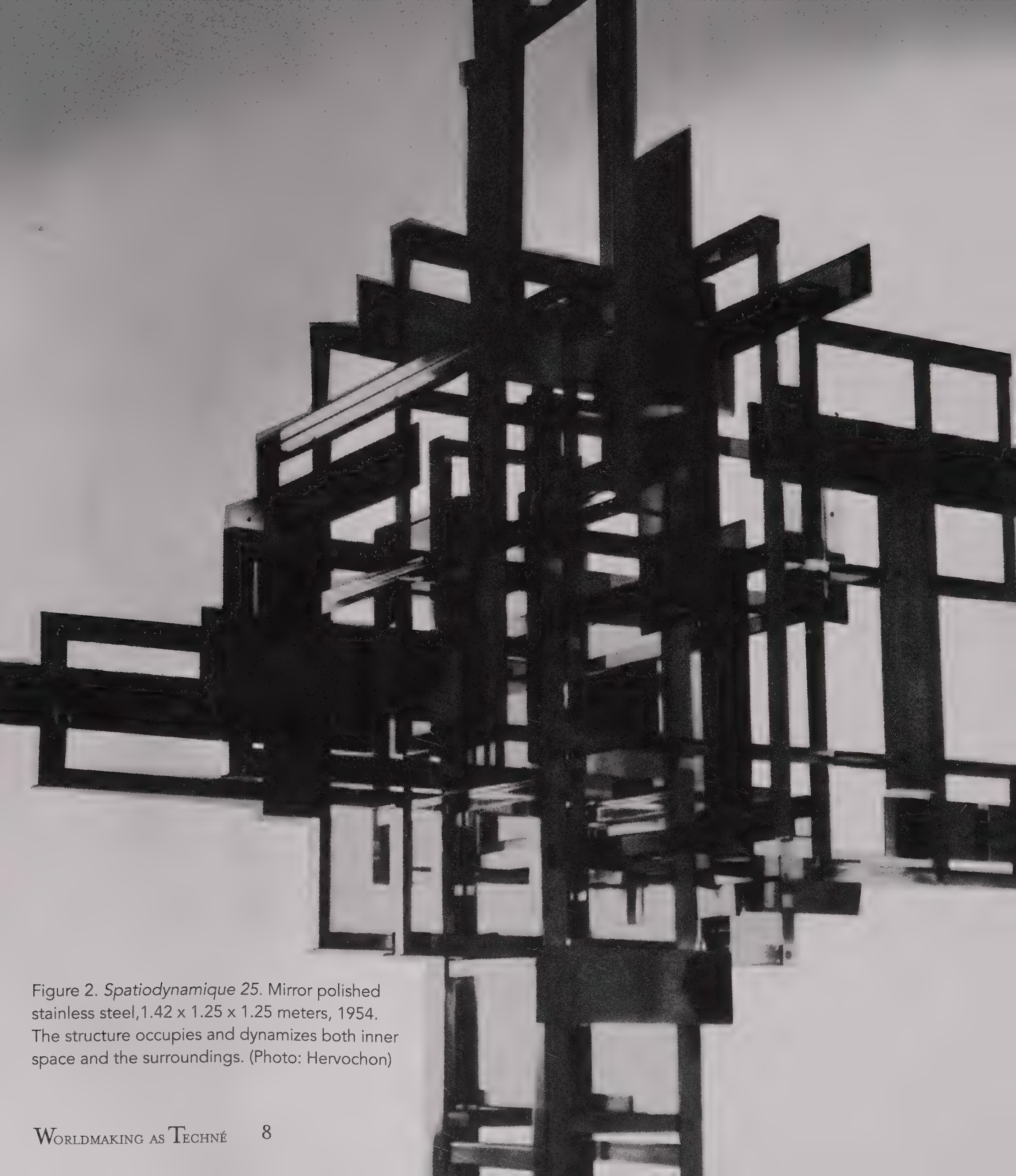

Figure 2. *Spatiodynamique 25.* Mirror polished stainless steel,1.42 x 1.25 x 1.25 meters, 1954. The structure occupies and dynamizes both inner space and the surroundings. (Photo: Hervochon)

disappear in order to return again, in accord with the fluctuations in the programmed rhythm of the human environment.

Enclosing a musical work within a concert hall for a limited period with an equally limited public is as 'antisociocultural'[4] as enclosing visual works inside museums with limited spaces and entrance fees. But, while visual art, through architecture and sculpture, has broken down these barriers, music remains enclosed, if only inside appliances such as radios, record players, tape recorders or television sets.

We must liberate music!

Liberating Music

Let us consider music an open and polyvalent structure. Through music's interaction with the environment, and thanks to its permanent availability, a combinative process can be derived to expose its multiple, even infinite, facets.

Music thus perceived becomes both permanent and contingent: it appears in an ensemble of programs when necessary, without pre–set limitations; and the environment instigates its creation when necessary, in a register harmonious with the spatio-temporal ensemble of which it is a major component[5]. Its visual corollary – a visual structure corresponding to the sonic one – works in symbiosis with it, in parallel, contrapuntal, or contradictory fashion.

Now we come to the fundamental problem which is at the root of everything: creation[6].

II. REFLECTIONS ABOUT CREATION AND SOCIETY

From the moment visual or sonic art is liberated from its traditional temporal and spatial bounds and dynamically inserted in the city, it no longer concerns some individuals only, but the society itself. And as soon as sound takes place in social life, it can only be as a permanence, fluently programmed by its environment, not a concert piece with definite beginning and end. This permanence is a continuous creation related to the basic creation of the sonic structures by the artist.

[4] In my writings, I have been induced to create new words or to modify existing words to imbue them with new significance. Here, I have joined 'social' and 'cultural' in keeping with my native Hungarian language. I have then further altered the resulting single adjective with the prefix 'anti'. In N. Schöffer, *Perturbation et Chronocratie* (Paris: Editions Denoël/Gonthier, Grand Format Mediation, 1978) 1st Part, I develop a method for extending the language and the conceptual world attached to it by what I call 'la Trialectique'. With this method any prefix can be added to any concept or word to produce various nuances. For example: culture-anticulture-proculture-retroculture-subculture-transculture-etc. This 'explosion' of the language leads to an expansion of understanding and liberates us from the linear, binary dialectic system in which we are all prisoners.

[5] Schöffer [3] "Topologie des rythmes", pp. 138–140; "Topologie de l'audible, organisation de la densité des événements visuels et sonores", pp. 143–145; "Schéma III", p. 215. N. Schöffer, *La Nouvelle Charte de la Ville* (Paris: Denoël/Gonthier, Bibl. Médiation, No. 119, 1974) "Les Topologies des sons", pp. 34, 60—62.

[6] N. Schöffer, *Le Nouvel Esprit Artistique* (Paris: Denoël/Gonthier, Bibl. Mediation, No. 72, 1970) "Mécanismes de la création", pp. 122–125 with schema and "Les trois étapes de la sculpture dynamique", pp. 24–46.

Sonic Structures

From this point on I shall speak of sonic structures rather than music. Why structures? Because henceforth we are no longer creating a work, we are creating creation[7].

Instead of setting up a program, we determine with maximum rigor a certain number of sonic (or visual) parameters whose harmonic structures have shared characteristics. Each parameter is itself a developed structure, and in order to 'optimize' combinations of parameters we assign perceptibly different qualities to each. Thus we are able to bring forth, through combinations of parameters, results not only without redundancy but which go beyond the intentions of their originators, and this in infinite number[8].

The first phase of creation is strongly determinative. The resulting second phase is contingent and spontaneous but governed by the quality and exactness of the web from which it has come and whose indelible mark it bears.

The Effects of Television

Why is television so fascinating, if not because the translucent rectangle is a source of continually renewed images? Each time we turn it on, we know we will see something new once again. For the first time, a machine delivering non-redundancy has been socialized on a global scale.

This is an event of considerable importance and one of the great disruptions of history. Its consequences will determine the future. This availability of non-redundancy through television causes a growing appetite for non-redundancy of visual information. Redundancy and stability need no longer be perceived in the same manner, and consequently two reactions will dominate: either a total lack of interest in everything that is static or repetitive, or on the contrary a preference for rigidity and redundancy, depending on the environmental or momentary conditions and the personal characteristics of the consumers. I believe that from now on we can almost certainly presume that instability will dominate.

Moreover, the destabilization of the media-dominated society has already begun, with consequences we cannot yet foresee. Classic and

[7] "The artist no longer creates a work, he creates creation." A spatio-lumino-chrono-dynamic work is an ensemble composed of two groups of parameters. Each group is commanded by a combinator. Since both combinators have two different speeds, their programs combine in a non-predetermined way. The results, i.e. visual information (or sonic information in the case of sonic structures), are constantly diversified, as are the effects produced by this ensemble on the spectator-auditor. This diversified production is infinite when the result of a number of parameters. For instance 150 parameters give birth to: 1 X 2 X 3 X 4 X 5 X 6 X...X 150 unique possibilities, which is 'infinite' to our capacity of observation.

With some other works (such as the Graphilux) I create 'creativity' which is the impulse for a new creation; through such works children and even adults become in a way the 'creative creation of my creation'.

[8] According to the number of parameters and combinators (in the case of 'programmed structures') or according to the types and quantity of information coming from the environment combined with the artistic programs, translated into artistic effects (in the case of 'cybernetic structures'), one can obtain an infinite number of effects.

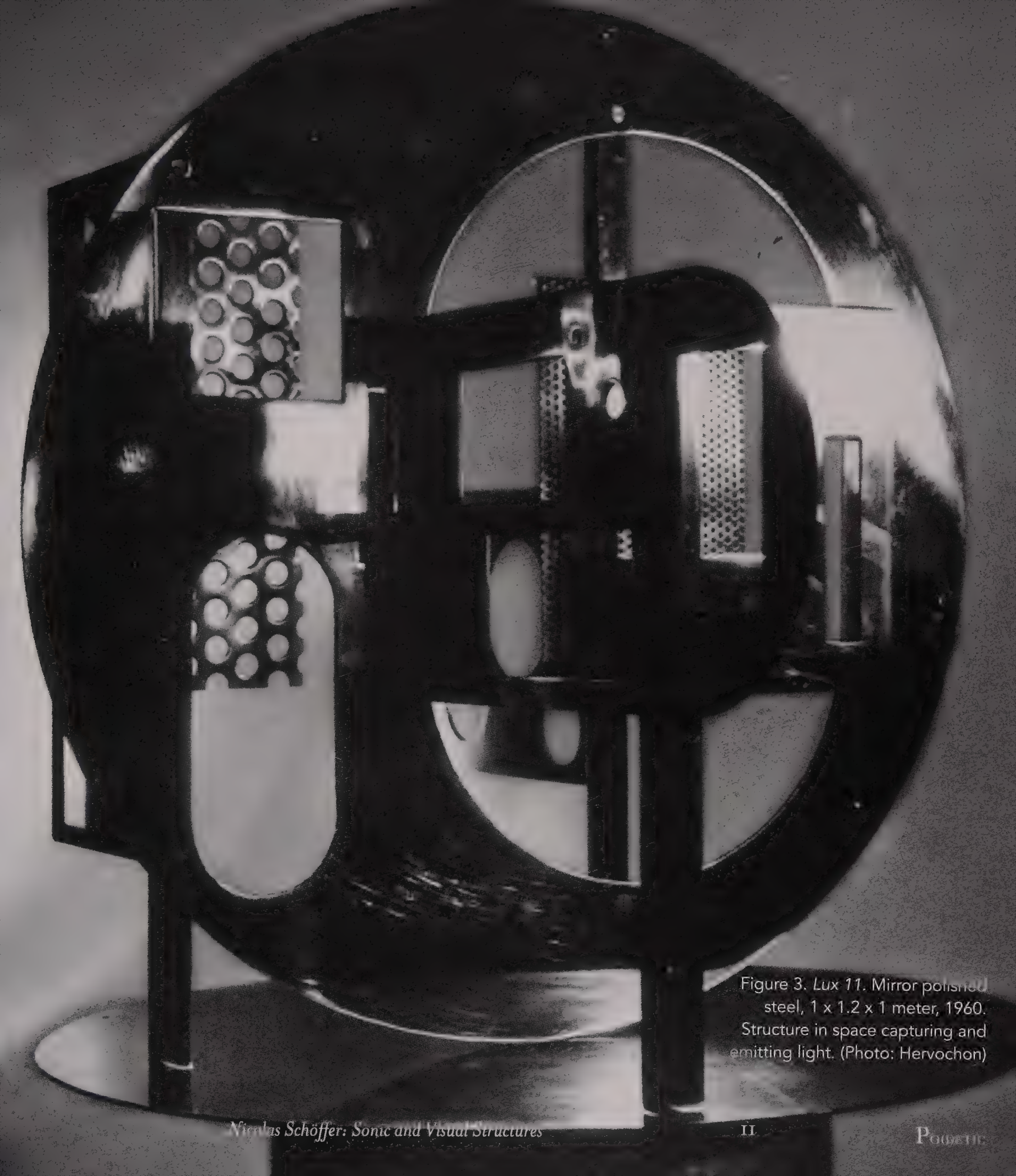

Figure 3. *Lux 11*. Mirror polished steel, 1 x 1.2 x 1 meter, 1960. Structure in space capturing and emitting light. (Photo: Hervochon)

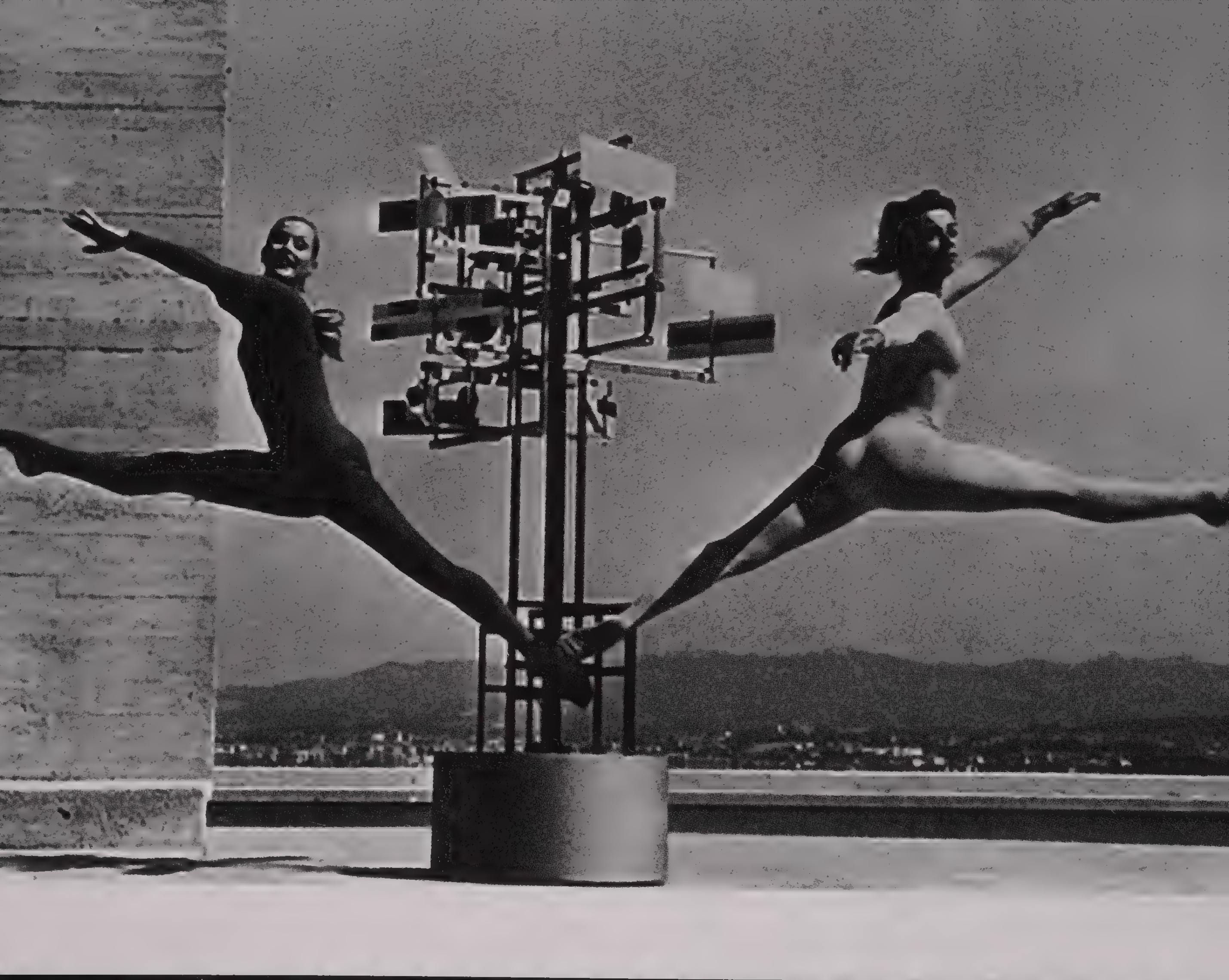

Figure 4. *Cysp I.* Aluminum and mixed media (computer, traction motor, direction motor, 2 microphones, 2 photoelectric cells, 19 micromotors), height 2.6 meters, 1956. Autonomic cybernetic sculpture with two ballerinas from the Bejart Ballet, on the roof of the Cité Radieuse of Le Corbusier, Marseille, 1956. This is the first sculpture to have a human-like self-determined behavior: the information received by the microphones, electronic eyes, etc., once processed, induces the sculpture to react (lights, motions, movements sounds, etc.) according to the events evolving or occurring in its environment.

traditional artistic techniques will surely no longer be able to strike massively and socially, except to encourage those who are nostalgic for a flight into the past.

Non-Redundant Art

The only operative intervention I see that will slow the inertial force of history is non-redundant art which, 'mediatized' and 'socialized' – especially in the urban setting – will take the collective rhythm[9] in hand by structuring it and making it aesthetic. More and more punctuated by a non-redundant and varied audiovisual art, the forward movement of history will then simply become a true progression[10].

In order to avoid any preliminary censorship at this point and to emphasize better the effects of this art, some counterpoints, if not whole sequences of redundancy (effects in which repetition, periodical returns, are obvious and perceptible), could be reintroduced as a contrast. Let us not forget, moreover, that diversity itself has its saturation points and its non-formalized redundancies.

Art is a subtle navigation between the snags of redundancy and multi-form information overload.

It is from these premises that I first developed my visual experiments and then, much later, my sonic experiments[11].

III. RESEARCH, EXPERIMENTS, REALIZATIONS

I began my first experiments in 1948 (Fig. 1 illustrates the development of my work in various media). After numerous technical experiments investigating the coordination of the speed of creation at the level of my imagination with the speed of manual execution, I became aware of the impossibility of adequate coordination due to the rapid process of the imagination, which the hand cannot follow. Subsequently, I decided to give free rein to my imagination and recorded internally the result of my mental activity. Once the creative process was finished, I laid out the schemes which allowed me to realize my spatio-, lumino- and chrono-dynamic programs – that is to say, to program successively space, light and time, this latter being

[9] The collective rhythm is the dynamic effect that emerges from the continuity of the life of groups. For instance the life of a town has its own time characteristics different from those of a village or a desert. People wake up, move about, stop, work, eat, communicate and so on. The town awakes, becomes excited or relaxes differently according to the days, the moments of the year, the climate, etc.

[10] Instead of explaining what is or would be a 'simple and true progression', let us consider a 'fuite en avant', a period of disorder when people turn to nonorganic solutions to their problems (alcohol, drugs, tobacco, suicide, wars, etc.). Progression, or progress, is simply the result of a real and constructive logic in the behavior of individuals and society.

[11] Schöffer [6] "Existence et persistance – son et vision", pp. 127–142, dated 1965. In fact, the first nontheoretical sound research started in 1977.

the parameter shared with music[12]. The first idea led to metallic sculptures – Spatiodynamiques (Fig. 2) – whose proportions modified the inner and external spaces which their structure delimited. Thus the potential dynamism of space became perceptible to the senses.

The second idea led to the Lux series (Fig. 3), which modified and exalted the intrinsic dynamic quality of space and light in a metallic structure endowed with reflecting plates drilled with holes of different sizes and with external white or colored light sources.

The third idea led me to 'dynamize' time in sculptures called Chronos (Fig. 8), including spatial and light moving elements such as stainless steel mirrors that rotate at certain speeds or stop according to a program distinct from that of the projectors integrated in the sculptures. The combination of these two programs resulted in a new contingent program, with visual effects that were non-redundant and infinite.

For these programmings (Fig. 4), I also allowed for the use of self–regulating cybernetic systems[13]. The currents and treatment of surrounding information gave my sculpture a retroactive behavior harmoniously linked to the environment[14].

All my space and time structures have been worked out on frameworks based on harmonics derived from the Golden Ratio, which I obtained through simple mathematics[15]. The result of the work of imagination – freely and instinctively visualized – was later set on these frameworks. This was further materialized in files containing blueprints of structures worked out in both space and time and organized on the same framework of harmonics (Fig. 5). Thus were born a great number of files, of which only a few cybernetic towers have been executed since 1954.

This work continued until 1977,when a new element entered my experiments in the form of an electronic organ. I discovered that the flexible mechanism of the organ, containing 8 octaves of sounds and 84 parameters of commands combinable with each other, offered me the exceptional capability to create sonic structures with my hands moving at the very speed of my imagination and to record them immediately with a tape recorder connected to the organ.

[12] N. Schöffer, *Le Spatiodynamisme*, text of a lecture given at the Sorbonne, 19 June 1954 (Boulogne s/Seine: Art d'Aujourd' hui Ed., 1954). See also Schöffer [6] Chapter 3, pp. 71–101. The 'spatiodynamisme' theory has given birth to a series of sculptures called Spatiodynamique 1 to 26 (1948-1958).

Schöffer, *La Nouvelle Charte* ... [5] "Le Luminodynamisme", pp. 31, 32, 56–60. The 'luminodynamisme' theory has given birth to a series of works (1956–1977) called Lux 1 to 13; *The Musiscope* (1963); *The Luminoscope* 1.2.3.; *The Téléluminoscope*; *The Mur Lumière*; *The Lumino*; *The Minieffets*; and recently *Murlux*, a 'luminodynamic tapestry' (1977).

Schöffer [6] and [3] pp. 95–99, 203–211. Since 1959, the 'chronodynamisme' theory has given birth to the sculptures Chronos 1 to 24, Microtemps 1 to 35, the 'automobile sculpture' *SCAM 1.* and large installations such as *Chronos 10* in Munich, Germany, 1980 (16 meters high), in Paris, 1980 (10 meters high), Chronos 15, in Bonn, Germany, 1977 (20 meters high), in San Francisco (20 meters).

[13] Schöffer [6] pp. 32–46. The 'spatio-lumino-chronodynamisme' leads to the programming of the five topologies (space, light, time, climate and sound) either by contingent programs or by cybernetics.

N. Wiener, *Cybernétique et Société* (Paris: Ed. des Deux-Rives, 1949) a translation

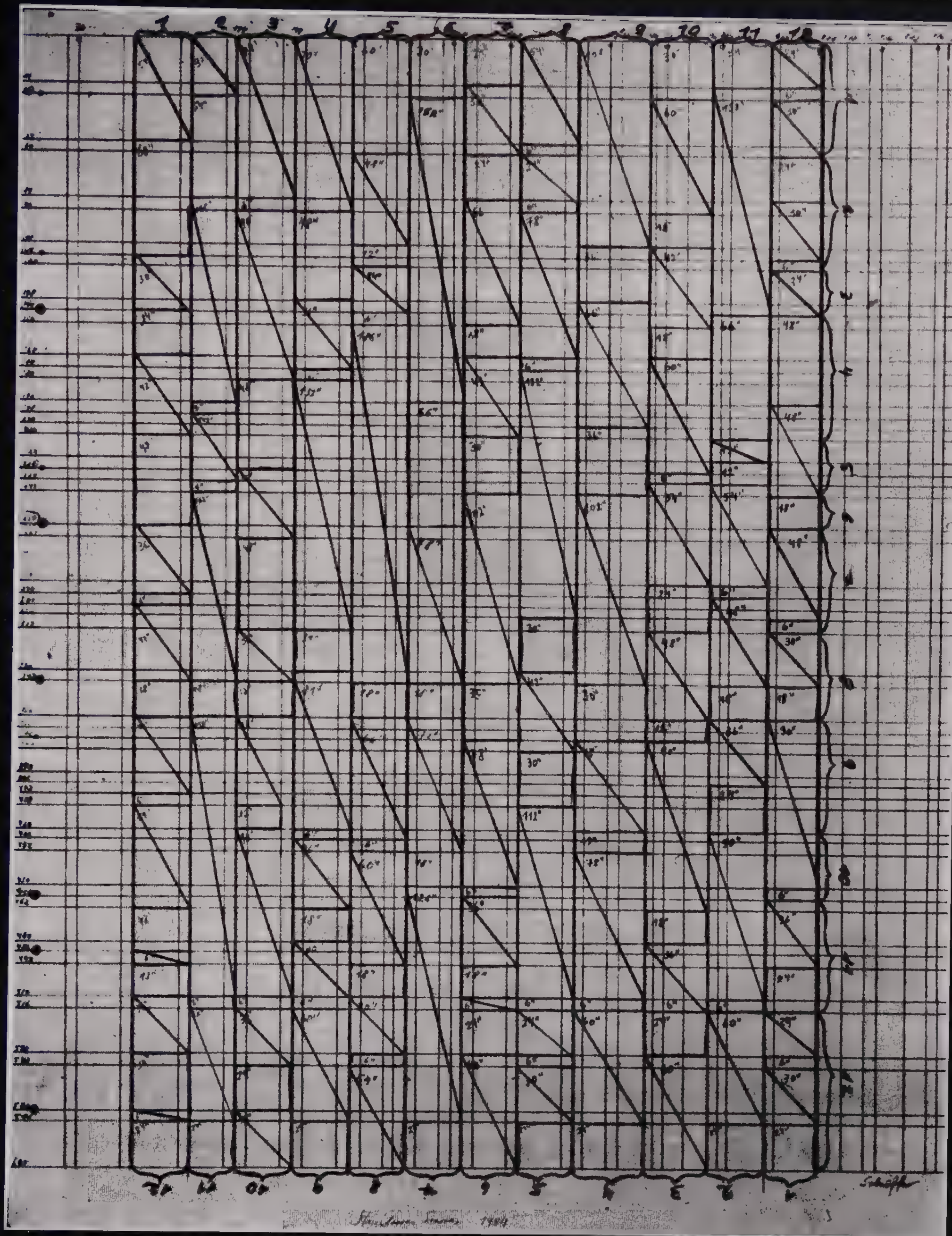

Figure 5. "Partition mobile pour Structures Sonores sur 4 X (IRCAM)". This score of a sonic structure built on a 'regulating frame' allows the development of a permanent sonic combinatory whose evolution is undeterminable. Here the harmonic frame derives from the number 600 and, of course, from the Golden Number (1.618).

Figure 6. *Tour Lumiere Cybernetique of Paris–la–Defense* (unrealized). Steel painted with epoxyl and a complex cybernetic system related to near and far environmental information; height of unrealized tower: 327 meters; first public presentation of the project, 1963. This maquette represents the Tour Lumiere Cybernetique of Paris–La–Defense functioning fully in the middle of its urban space, thus reacting to the information characteristic of the life of the town (traffic, mail, stock exchange, trains, helicopters, planes, winds, temperature, etc.)

Free from any classical or contemporary musical training, I familiarized myself with the organ, exploring its non-musical, i.e. pure combinatory, possibilities. Then, as a creator of programs, I began a process which was the opposite of the 'demanualization' of my visual experiments and which led me to use my hands as the synchronous extension of my imagination[16].

My essential problem in developing a sonic structure is maintaining constant contact with the creative thread unraveling on the level of my imagination. The unfolding idea must be followed unfailingly to its outermost limit by the play of my hands manipulating the organ in the broadest possible and most effective manner. Within the time I allow for any sonic structure, the idea must be clearly developed and its nature revealed. The elements composing the whole must create a solid structure with harmonious temporal proportions and whose sonic sequences bring out a mobilizing, if not fascinating, effect.

In determining whether a sonic structure is a 'success', I consider the most important parameter to be the proportional relationships established during the performance of the piece. I consider the sonic structures I have produced with the electronic organ successful to the extent that there was coordination between the imagination and the execution.

Framework, Coding and Programming

Every creator of sonic or visual art reveals and develops a framework. The harmonics of the framework in some sense mirror the complex structures which make us what we are and act upon our programs, regulating them according to each person's specific rhythms.

The approach toward these rhythms hidden in the depths of our consciousness is difficult, yet frees our intuition and basic instincts. Both emerge from us temporarily and punctually and transcribe themselves into all kinds of visual, sonic, or audio-visual structures. Concretized in the domain of art, these structures constitute works coded and programmed in time and space.

The decoding of these works and the communication that follows cause psychosociological repercussions more or less profound, depending on the quality and topicality of the programs. But the concretization

from *Cybernetics and Society – The Human Use of Human Being* (1949).

Here my definition of 'cybernetics' may be useful:

"Cybernetics is the awareness of the process that keeps phenomena in balance. It is the science of efficiency and government by the organized control of all information, including the data that concern perturbations of every kind. These perturbations are processed so as to achieve the optimum regulation of every organic, physical or aesthetic phenomenon. The result is therefore a fluid permanence in flexible balance. In this balance every appearance of a tendency toward periodicity or stagnation triggers the intervention of the perturbations needed to maintain the openness and the contingent character of any evolving process."

[14] Schöffer [3] p. 105. Before *Cysp 1.*, a 50-meter-high Cybernetic Tower was built in St. Cloud in 1954, followed by the 54-meter-high Cybernetic and Sonorous Tower of Liège (Belgium, 1961). The last cybernetic tower (26 meters high) was built in Kalocsa, Hungary, in 1982 with a sophisticated technology and vertical projections 2 km high. The T.L.C. (*Tour Lumière Cybernétique*) of Paris-La-Défense (327 meters high) has not been built. See N. Schöffer, *La Tour Lumière Cybernétique* (Paris: Denoël/Gonthier, Grand Format Médiations, 1973).

[15] Matila Ghyka, *Le Nombre d'Or* (Les Rites, Vol. II) *Philoso-*

phie et Mystère du Nombre (Paris: Payot, 1979); Chapter V in Schöffer [3] p. 47.

[16] N. Schöffer, *Hommage à Bartok* (Budapest: Hungaroton, 33 tours, 1979).

[17] The plans of the *Cenotaph of Newton* (1784), of the revolutionary architect Étienne-Louis Boullée. constitute an available coded treasure that could be built at any moment.

[18] Schöffer [4]; N. Schöffer, *La Théorie des Miroirs* (Paris: Belfond, 1981).

of the works rarely occurs immediately because of their complexity and the newness of the language and the combinations. For these reasons, the coding and preservation of programs are essential. At the opportune moment, the programs must be in a state of readiness to be executed, diffused and communicated. Shakespeare, Boullée, De La Tour, Vermeer, J.S. Bach and Varèse all fixed and coded messages which were not immediately communicated[17].

Apart from any desire to over- or underestimate the products of imagination or to presume their value, just in order to better understand and control one's actions, each creator would do well to preserve his or her programs, whether these be executed and recorded or coded and indexed, or both. Thus one can maintain the possibility of a later easy decoding and have a reserve from which to reconvert or recombine programs.

Personally, I consider my sonic structures recorded on tape, indexed and computed according to their characteristics, to be a growing library from which I can draw. By inserting whole selected structures or only certain fragments of them into new structures, new frameworks, I can create combinations capable of revealing new perspectives.

Today all this is made considerably easier by the use of computers, those powerful electronic extensions of mankind, conceived by humans. Here the notion of 'the creation of creation' becomes an obvious reality. The computer can explore and choose, or can at least easily and rapidly present us with, series of combinations by which our own choice is facilitated to create and recreate multiple solutions in multiple directions, each having the trademark and quality of the basic programs while differing fundamentally from them[18].

The Explosion of Ideas

Among the many varied explosions which characterize our time, I see demography, technology, production and consumption as the main ones. But the most important, concerning all of them, is probably the explosion of quality joined to the explosion of quantity. The growth of demography, technology, production and consumption in quantity has allowed the number of elements of quality to grow in quantity. This leads to growth in

Figure 7. *The Prism*. Mirrors and a translucent screen receiving luminodynamic projections (various scales), first exhibition 1955. The triangular arrangement of mirrors and screen transforms the space into a multiple glittering series of surfaces receiving luminodynamic projections. Thus a virtually unlimited space is created, in which a single figure and a laser are multiplied to infinity.

Figure 8. *Chronos 15* in its half-contemporary, half-ancient environment in Bonn, West Germany; stainless steel programmed structure with mirrors, 1977. Night view of the sculpture in action. This can easily and quickly be modified into a cybernetic sculpture.

the quantity of the quality itself. Yet, these four explosions characteristic of contemporary life are practically insignificant compared to the explosion of ideas, particularly in the fields of artistic creation, philosophy, sociology and the theoretical sciences. These ideas are exploding even though their effects are not always immediately perceived. Their diffusion varies according to the opportunities afforded them by the era, and very frequently they emerge abruptly or progressively after long periods of incubation[19]. Be that as it may, the finality of true creation is found first in itself and not in its ultimate 'socialization', or popularization. The Cybernetic Light Tower of La–Defense (Paris) (see Fig. 6) is a non-realized project but, thanks to information of all kinds, it already belongs to the memorized and probably archetypalized repertory of the significant works in the domain of the plastic arts.

Creator–Sower

Sowing the seed is a necessary precondition to subsequent harvesting. The true creator is a seed-sower. The soil is not always sufficiently fertile for the crop to come forth, but the role of the sower is not to prepare nor to enrich the field. That is the role of education and mass media[20].

A fertile and fertilizing idea is a dense and solid concentration of idea-parameters rigorously dosed out and structured through a combinatory process broadly opened out for the blossoming of a multitude of information. The more simple and rigorous the basic parameters, the more diverse, varied and rich are the combinations which offer infinite information.

This idea can be seen in The Prism (Fig. 7), where space bounded by three panels covered with mirrors is set in the form of an equilateral triangle. The triangle is opened on one side and closed on the other by a translucent screen. Simple mechanisms behind the screen program variously perforated shutters and polychromatic and rhythmic luminescent sources in combinations sent out over the bursting surface. The threefold shimmering panel becomes an endlessly varied play of non-repetitive colored projections [21]. This process of reverberation seen in The Prism is transposable to the field of sound, thanks to the computer.

The sonic structures I prepare allow one to select the parameters to be introduced in varied combinations. Through the careful proportioning of

[19] Schöffer [18].

[20] One of the roles of the media should be to inform people about the evolution of artistic ideas and of new research connected with new techniques, to create a climate of suspense for great cultural events and important artistic realizations, as well as to create a feeling of respect, love and pride for the patrimony of the past, the present and the future. The media has succeeded perfectly regarding its similar role in the domains of technology, science, and particularly politics and sports (even criminology) but has failed in its main vocation. It has focused the interest of people on the commercial phenomenon which presents art as a production of merchandise, with its prices, speculations and so on. This has nothing to do with art and the fundamental research that corresponds to the real level of civilization. This does not prepare people to understand and appreciate the world of artistic creation, nor to participate in it, as it should.

[21] According to these principles, five *Prisms* have been realized (1 to 5), (1965), as well as a *Grand Prisme* of 20 meters for *Kyldex I.*, a cybernetic experiment with music by Pierre Henry and choreography by Alvin Nikolais at the Hamburg State Opera (1973), and another cybernetic experiment with computer music composed by Pierre Barbaud (1975) at the Chapelle de la Sorbonne, Paris. Recently, an 8-meter-high Prisme has been installed in the

Museum of Fine Arts, Budapest, Hungary (1982).

Projects of Centres de Réflexion and Videotrons are already coded and described in Reference [4] pp. 125–127, 215–231 and in Reference [18] p. 114.

[22] Schöffer [3].

speeds, reverberations and inversions, infinitely variable programs can be established. Traditional time limits are thus exploded and yield to permanencies capable of being hidden or revealed according to the demands of the environment[22].

IV. FUTURE PERSPECTIVE FOR MUSIC AND THE CITY

Among the spaces perceived by man, the urban space holds a privileged place. While interior living spaces concern restricted groups, the city is at the disposal of the masses. The pieces of information received in the enlarged urban space have a primordial importance in the formation and the behavior of all who reside or enter there. This consumable and constantly consumed space, both determined and nourished by its consumers, must therefore be developed with maximum care by making the determining structures optimum. The essential components of these structures are visual and sonic information (Fig. 8).

A city is but a constant audiovisual performance whose unfolding is contingent, where the decors are both static and dynamic, where the actors are also spectators, and where the musical accompaniment originates automatically from sounds caused by diverse visual parameters in varied and variable movements.

The Staging of Cities

While visual parameters are laid out taking into account certain functional and sometimes aesthetic rules, the sounds they engender by their movements and reverberations are fortuitous, even anarchical, and certainly not aesthetic. Therein lies a serious error in staging. My first automobile sculpture, Scam I (Fig. 9), was realized with the intention of introducing an aesthetic perturbation into the urban space. Instead of being fixed somewhere in the town – as sculptures are usually – Scam was able to move around and participate in the collective spectacle or spontaneous choreography of the normal circulation of vehicles and people in the streets and places dedicated to traffic.

The term 'staging' does not necessarily imply a fixed prescription of programs. Rather, contingent programs prepared from certain

Figure 9. *Scam I* circulating in the middle of urban traffic in Milano, Italy, 1973. *Chronos 10* was fixed on a chassis specially conceived and constructed by the Renault Auto Company with a body specifically designed and executed by Coggiola in Torino, Italy. *Scam* was meant to meet people in the street without any spatial limitation, thus increasing the social impact of traditional static sculpture, set up in a precise spot in the city. Here the impression of rush hour traffic in a Milano avenue is aesthetically disturbed by *Scam*.

constituent sonic elements rigorously selected and combined will always be adapted to their visual environment. This staging also concerns filling sonically empty spaces with integrated sonic structures. These structures should therefore either replace the anarchic sound of frequently harmful noises which invade the urban space or integrate these noises into a context where they serve their intended function without disrupting a programmed sound combination which should be flexible and adapted to the collective life that is the city.

Let us take up again the term 'music'. Far more important than that of concert halls, the music of cities involves in its creation a public actively participating, collectively or individually, as producer or consumer.

It is necessary that music, like the visual arts, be socialized. Placed at the disposition of the masses, it must finally 'de-passivate' mankind. Up to now, mankind has been condemned to receive. Respectfully seated most of the time – whether in concert halls, at the opera, in theaters, in front of televisions or beside transistors – people receive auditory and audiovisual information whose unfolding and content they cannot modify.

Activated Humans

Passivated humans, humans made passive, ready to be manipulated, more and more sheep-like, have created a tentacular system of adulterated media. In order to avoid drowning, let us introduce creation, creativity, into the spaces available to the public. Collective spaces allowing for the participation of everyone will revivify the spirit of groups faced with noble and aesthetic collective actions.

A collective choreography would incorporate the movements of each person, with costumes and colors judiciously chosen, structured sounds combined and programmed contingently, and mobile decors also programmed – all in diversified spaces. This is how to de-passivate the external space, that active and animated space of cities where so many are called to be spectator and actor.

The music of cities is called upon to replace the noise of cities, and, when necessary, the silence of cities.

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***

GLOSSARY

demanualization- a neologism concerning the importance of the hand in the creative process; but, the hand, being too slow compared to the speed of the imagination, is put aside and quicker techniques are used.

diffusion- both spreading and techniques of spreading.

harmonics- The Golden Ratio (Phi: 1.618) allows for the development of a 'series of harmonic numbers'. These are related to 1.618 as well as to one another according to a 'harmonious proportion'. The dimensions of the sculpture and the duration of its program are calculated to obtain a series of harmonic numbers among which the characteristics of the sculpture are chosen. For instance, the basic number is the height of the sculpture. This number will be multiplied or divided by Phi. Any other arithmetic operation between those two numbers will give other numbers, and all of them will constitute 'a series of harmonics of the Golden Ratio', some of them having an 'optimum' quality. This is the repertory from which we can extract the different numbers necessary to structure, or compose, the numerous parts of our 'spatio-lumino-chrono-dynamic programs': height, width, thickness of the metal bars, distances between holes, diameters of the plates, number of elements, surfaces, durations and so on.

mediatized- distributed and expanded through the media and, in that way, poured into society: 'socialized'.

optimum, maximum- the difference between 'optimum' and 'maximum' being that of quality and quantity, to 'optimize' means 'to bring to the utmost quality'.

passivated man (in French, 'depassiver', 'depassivation')- a 'passivated man' is not a 'passive man'. 'Passivated' or 'passivized' implies that various factors in life, such as those described, have made people passive. In this neologism the emphasis is on the active responsibility of these factors and on the fact that it is not a normal state supposed to last. A certain hypnotism is implied, a certain 'sleep' from which humans should awake. The problem of 'activation' or 'depassivation' of people then arises in the minds of those who are conscious of the situation. It is part of the role of the true artist to find and propose solutions to this problem.

polyvalent structure- a structure that combines a certain number of parameters such as percussions, high pitch sonorities, low pitch sonorities, accelerations, infrasounds, different kinds of timbres, etc., each part capable of being used separately or attached to other parameters.

program- a fixed or contingent plan determined by people (their habits, rhythms, tastes, research, etc.) and/or imposed on groups (professions, collective schedules, holidays, school periods, etc.).

register- a group of specific parameters which evolve on a definite level.

to socialize, socialization (in French 'socialiser')- I created these neologisms independent of any political content. Art is not a merchandise and should not fall into the system of commercial speculations nor caste privileges. Art exists for society, for the city, for a better life and, through harmony, wonder and...perturbations, should help people transcend their materialistic conditions.

Inventing Causalities and Networks of Influence

Alberto de Campo

Worldmaking and Causality

The world human beings live in, the models of it created by human beings aiming to understand it, and especially the worlds created for artistic contexts are defined in essence by the rules that observers infer to apply within them. Very generally speaking, living organisms develop ways to "figure out how the world works," and then attempting to influence it well enough to fulfill their desires, whatever these may be. The process of figuring out which rules work well is informed by intuition (relying on biological mechanisms and instincts), and with human beings, by inducing general principles from continued observation.

When making worlds, no matter how small or big, this process is inverted: artists can choose the rules that will apply, and they may aspire (and I do) to create or find rules that deviate from the obvious ones in nontrivial ways. Ideally, the created world will not just provide a strong experience of its particular content, but also an intriguing experience that invites hypothesizing about its inner logic by observing its behavior, especially when the inferred mechanisms of this world make it unique.

The idea of *causality* is a stricter conceptualization of the notion of such rules, and it has been an important concern for humankind for millennia. In this article I aim to cover a wide range of its context in varying depth: some biological and psychological underpinnings that inform practical causal attribution, and the history of causality as a philosophical idea is sketched briefly. Its more recent forms, from cybernetics to notions of all-pervasive agency will be discussed in more detail, in order to arrive at the notion of *networks of influence* as a richer and more flexible mental model of "how a world works". To contextualize the concepts developed within artistic practice, I discuss some of my own works and some art works or ideas they directly relate to. This form of analysis is intended to show how the concepts capture essential aspects of the pieces, ideally in ways that are insightful and informative for synthesis, i.e. for artists experimenting with the possibility spaces of strange and idiosyncratic world mechanisms.

Perspectives on Causality

This section briefly discusses common notions of *causation* and *causality* in different domains, in order to assemble a multi-faceted portrait of it. This is not an attempt to propose any solutions for philosophical or practical problems around these notions, but only to point out aspects in its rich history that I find relevant for the discussion of Worldmaking, and to assemble a basic vocabulary of causal mechanisms in order to play with them and consider how their variants differ in their implications.

Causality has been a major concern in Western societies – the practices of science, engineering, politics, economics, the law, and many others depend crucially on shared notions of which processes caused what effects, whom to praise for desirable achievements, and whom or what to blame for negative outcomes, from little glitches to large-scale catastrophes. Nonetheless, after millennia of philosophical and other studies of the concept, mankind has not reached agreement on just what causality is, how it is supposed to work, and how to unambiguously prove or disprove causal connections between events. Figure 1 shows a real world example for the complexity of causal connections and conditions – the circumstances and the reconstructed chain of events that led to the capsizing of the ferry *Herald of Free Enterprise* in 1987.

Causality also plays a big role in everyday practical life, when figuring out how everyday things work, from mechanical objects like knives to devices like bicycles to electronic machines such as laptop computers and mobile phones. This daily activity is firmly based on *final causality* – when I expect that doing X will result in Y, I can decide to do X in order to achieve Y – unless one adheres to ritualism; then, the aim is to achieve a world ordered according to the world model the ritual stems from.

"A world" can be understood as a running process where the entities contained continuously interact and influence each other, thus jointly forming an evolving state, a history of that world. For worldmakers, designing the "look and feel" of a world is only the surface; the specific character of that world rests in the mechanisms for interaction and intra-action designed into it. Raising the terminology from 'rules' of a world to 'causalities' emphasizes the centrality of causal thinking.

Biology, psychology, and decision theory

Living organisms survive by acting meaningfully within the environment they live in, and thus achieving what they want. This usually ranges from bare survival - defense against natural enemies, acquiring food - via all forms of procreation, possibly to higher order aims their species or communities may have evolved. Acting meaningfully requires a viable working understanding of how their world works, which usually involves observing essential aspects of the world, and registering *correlations* - for amoebas, that may be a correlation between their inner chemical balance and the level of acidity in the watery environment they live in. Sensing the gradient of acidity and then moving in the direction where the environment seems to become more suitable is such a meaningful action.

More complex organisms will appear to have intuitions about likely outcomes of possible actions, and make decisions about which actions to take. Any regularities in the observations of the world are useful for improving predictions about which actions will be useful, and can be attributed to mechanisms, which are actionable hypotheses about the world. With humans, the mechanisms are often formulated as patterns or rules, ranging from general abstract ones (say, a law of physics such as gravity) to the rich variety of patterns in the social behaviors of groups.

Obviously, causality is not an inherent property of the world itself; it is always interpreted into the world as a cognitive construction by a living being observing its environment, whether it remains a simple intuition or everyday opinion, or a complex conceptual abstraction. Usually this happens with the intention to control the flow of the world by being able to predict next events.

A closer look at how causal rules are formed reveals a tendency to simplify: for every physical experiment to run the exact same way again, many circumstances must be closely controlled - room temperature, humidity, light, freedom of external vibration, et cetera, and only under those conditions will the experiment have a chance to repeat its results closely enough. This relativizes the value of the reduction to a single cause, as is usual in the classical scientific method.[1] Both in lab settings and in everyday situations, expanding spheres of circumstances continue outward endlessly, and may influence outcomes in surprising degrees.[2]

[1] von Foerster, Heinz (2003). "Perception of the future and the future of perception." In: *Understanding Understanding*. Springer New York. pp. 203-204. Reprinted in this volume. Discusses the pitfalls of the scientific method excluding almost everything.

[2] H. Ross Ashby discusses a similar idea (variables being connected to an environment in time-varying degrees) in his talk and the ensuing discussion at the 9th Macy conference. Ashby (1952). Ashby, H. Ross (1952) Homeostasis. reprinted in: Pias (2003).

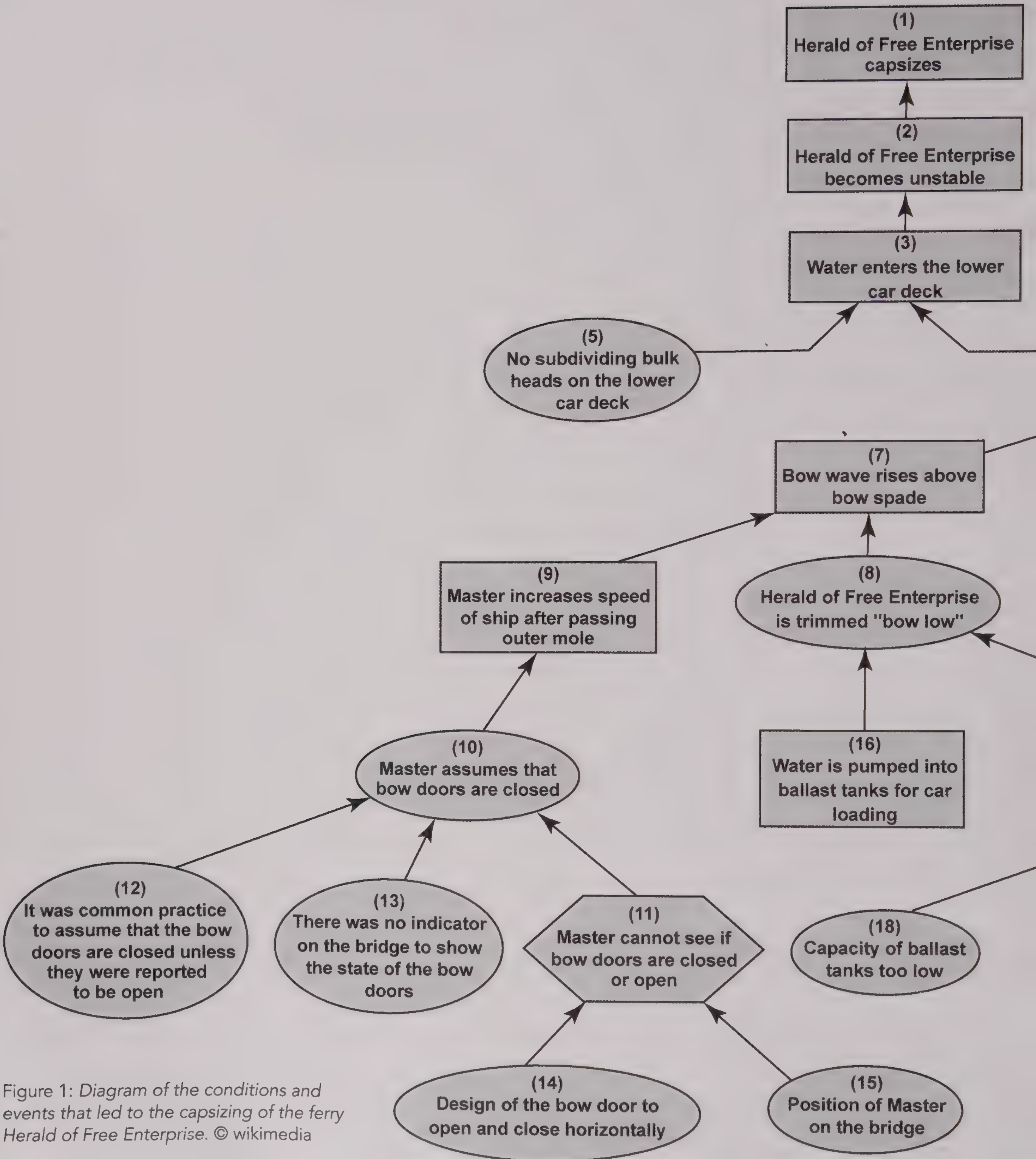
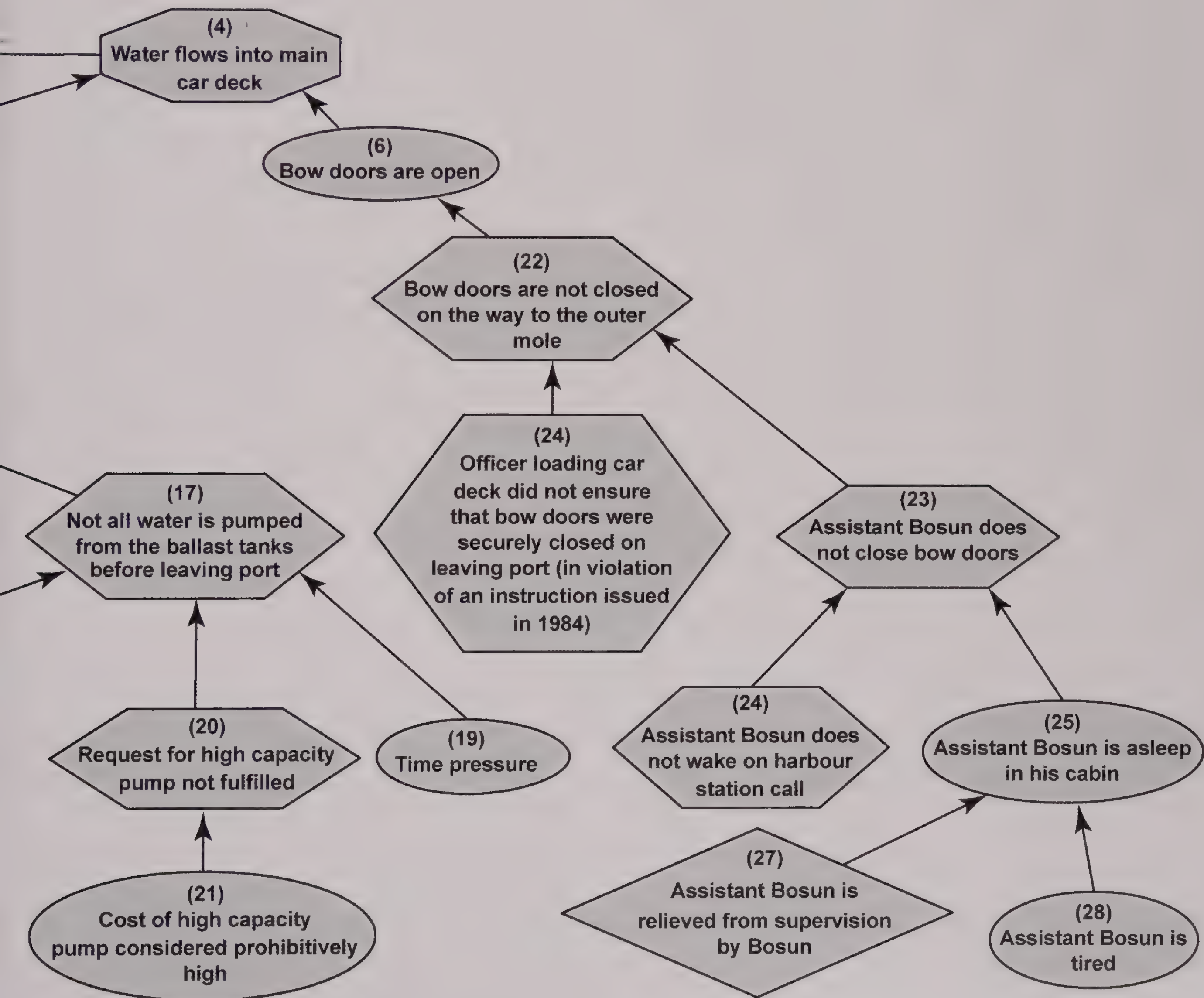


Figure 1: *Diagram of the conditions and events that led to the capsizing of the ferry Herald of Free Enterprise.* © wikimedia


(4)
Water flows into main car deck
(6)
Bow doors are open
(22)
Bow doors are not closed on the way to the outer mole
(24)
Officer loading car deck did not ensure that bow doors were securely closed on leaving port (in violation of an instruction issued in 1984)
(23)
Assistant Bosun does not close bow doors
(17)
Not all water is pumped from the ballast tanks before leaving port
(20)
Request for high capacity pump not fulfilled
(19)
Time pressure
(24)
Assistant Bosun does not wake on harbour station call
(25)
Assistant Bosun is asleep in his cabin
(21)
Cost of high capacity pump considered prohibitively high
(27)
Assistant Bosun is relieved from supervision by Bosun
(28)
Assistant Bosun is tired

Seismic recordings need ways to identify trucks going by too closely, and even in very well-isolated labs, cosmic particles may derail sensitive electronic equipment seriously. In Cold War times, solar storms were mistaken for signal jamming attempts by the enemy, and came dangerously close to triggering nuclear attack sequences.[3]

[3] Knipp, D. J., et al. (2016), The May 1967 Great Storm and Radio Disruption Event: Extreme Space Weather and Extraordinary Responses. Space Weather, 14, doi:10.1002/2016SW001423.

Social systems are much more subject to changes than physical ones, and so in the social sciences, awareness of changes in causal mechanisms is crucial. Political economist Albert Hirschman jokingly suggested to Clifford Geertz his Law No. 1 in the Social Sciences: "Whenever a phenomenon in the social world is fully explained, it ceases to operate."[4]

[4] Hirschman (1973), "Political Economics and Possibilism", foreword to "A Bias for Hope", reprinted in Adelman (2013), *The Essential Hirschman.*

Probably every textbook on statistics for the social sciences points out the difference between correlation and causality, often quoting a website that has collected highly entertaining examples of "spurious correlations"[5], such as that between 'number of people who died by becoming tangled in their bedsheets' and 'Total revenue generated by skiing facilities (US)' (a correlation of 0,97 for the years 2000-2009). By comparison, many Big Data analysis tools and services only consider correlations, and their providers nonetheless sell them as a solid base for 'scientifically informed' decisions.

[5] Vigen, Tyler (2009-) http://www.tylervigen.com/spurious-correlations

In *What About Mozart[6]*, Howard Becker explains how user groups for certain drugs change radically. In the early 20th century, well-to-do bourgeois housewives were the typical opiates user group; by the 1960s, this had changed to young black males from poor suburbs. (Opiates were legally sold in drugstores, and were prescribed by doctors against "female complaints"; when it became an illegal business, unemployed black males were recruited as small dealers and often became users themselves.) In Becker's words, A and B cause C until they don't anymore.

[6] Becker, Howard S. (2014). *What about Mozart? What about murder?: Reasoning from cases.* University of Chicago Press. p 66.

Human beings have a tendency to fill in missing details in patterns, for which Gestalt psychology has many examples, from recognizing semi-occluded objects as wholes to substituting drowned-out syllables in speech with something that works to create meaningful sentences. This extends to seeing patterns even when there are none. Psychologists call this phenomenon *apophenia*, and a special form of it, *face pareidolia[7]*, accounts for such unlikely perceptual events as seeing the face of Jesus on a piece of toast. While this tendency to perceptual pattern completion is extremely useful in some respects, it can become a fallacy in others.

[7] Liu, J., Li, J., Feng, L., Li, L., Tian, J., & Lee, K. (2014). Seeing Jesus in toast: neural and behavioral correlates of face pareidolia. Cortex, 53, 60-77.

Decision theory is a recent domain bridging psychology and economics that studies in depth the implicit mechanisms and strategies by which humans ponder and form decisions. These range from neurobiological underpinnings (like the limited number of independent items humans can typically hold in working memory[8]) to a variety of systematic psychological biases; from a multitude of cognitive fallacies that even experts in their own fields often fall for[9], to illusions of control[10], where people take absurd logical shortcuts in their explanations of how things work. One can say that this field explores *folk causality*. Daniel Kahneman received a Nobel prize for his work with Amos Tversky in this area[11], which co-defined the field of *behavioral economics*. It forms an influential countermodel to the *homo oeconomicus* (the model of rational human behavior where the individual always maximizes its own gains, which used to dominate economics) and provides the background for current accounts that apply neuropsychological insights to everyday life.[12]

Causality in philosophy

The article on causation in *The Dictionary of the History of Ideas* [13] names mythology or intervention by gods as the main reasons assumed by the ancient Greeks before the great philosophers for events in the world. Causality proper traditionally is considered to begin with Aristotle's definition of causes:

> Material cause – materials from which the object in question is made
>
> Formal cause – the object's form determines its properties
>
> Efficient cause – a force inducing movement in the object
>
> Final cause – the completion, the purpose of an action (such as making an object) and the intentions of the acting entities.

He further distinguished two modes of causation, proper and accidental (chance). This fourfold definition of causality dominated Western thought for the Middle Ages, and still is often referred to as the foundation of the concept. It was first questioned by precursors of a modern scientific stance (such as Francis Bacon), who tended to discredit final causation for events in the physical world, and this new view became the standard for scientific thinking.

[8] Miller proposes "seven, plus minus two"; recently, lower numbers have been proposed. See Miller, George A. (1956): "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." In: *The Psychological Review*, vol. 63, pp. 81-97. Online at: http://cogprints.org/730/1/miller.html accessed 05/08/2016

[9] Pohl, Rüdiger (2004). Cognitive illusions: A handbook on fallacies and biases in thinking, judgement and memory. Psychology Press, 2004.

[10] Langer, Ellen J. "The illusion of control." *Journal of personality and social psychology* 32.2 (1975): 311.

[11] Kahneman is a good introduction to decision theory. See: Kahneman, Daniel (2011). *Thinking, fast and slow.* Macmillan.

[12] Levitin, Daniel J. The organized mind: Thinking straight in the age of information overload. Penguin, 2014.

[13] Weinberg, Julius. Causation. In: *The Dictionary of the History of Ideas*, vol 1, pp 270-78. ed. Wiener, Philip P. Scribner, 1974.

The most fundamental critique of the assumptions implicit in Aristotelian causation came from David Hume[14], who pointed out the inevitable limitations in human cognition, and the leap of faith that occurs when progressing from an observed correlation to a causal law of nature. He questioned the absoluteness of causality by identifying it as human interpretation of events happening contiguously in time, and expressed fundamental doubts about the validity of induction in general – which is the only ground human beings have for assuming stability of the constants observed in nature, and the laws that seem to apply between them.

[14] Hume, David. "Philosophical essays concerning human understanding." A. Millar, 1748.

William James considered causality a metaphysical axiom and described the human desires around it very elegantly:

> "... these more metaphysical postulates of rationality ... have a fertility as ideals, and keep us uneasy and striving always to recast the world of sense until its lines become more congruent with theirs. Take for example the principle that 'nothing can happen without a cause.' We have no definite idea of what we mean by cause, or of what causality consists in. But the principle expresses a demand for some deeper sort of inward connection between phenomena than their merely habitual time-sequence seems to us to be. The word 'cause' is, in short, an altar to an unknown god; an empty pedestal still marking the place of a hoped-for statue."[15]

[15] James, William (1890). *The Principles of Psychology*, p 671. online at http://psychclassics.yorku.ca/James/Principles/index.htm

Bertrand Russell began an extended comment on causality[16] with the wish "to maintain that the word 'cause' is so inextricably bound up with misleading associations as to make its complete extrusion from the philosophical vocabulary desirable", and further claims that the law of causality as formulated by philosophers is useless and not actually used in science at all.

[16] Russell, Bertrand. "On the notion of cause." Proceedings of the Aristotelian society. Vol. 13. Aristotelian Society, Wiley, 1912.

More recently, Quentin Meillassoux bases his hypothesis of hyperchaos[17] on the grounds of Hume's skepticism – in principle, just because the world appears to follow stable laws does not permit humans to assume it will stay that way. The universe might at any point fall into other modes with potentially radically different laws of nature.

[17] Meillassoux, Quentin (2010). *After finitude: An essay on the necessity of contingency*. Bloomsbury Publishing.

Cybernetics, Circular Causality, and Radical Constructivism

Cyberneticians were involved in two major scientific insights of the 20th century: the notion of *circular causality*, and the invention of the *observer*. Given that cybernetics in popular perception has mainly been reduced to a prefix/cipher ominously marking the dark side of technology (289 million google hits for *cyber-*), it seems appropriate to briefly contextualize both its first and second order variants here.

Cybernetics is a meta-discipline, which aims to describe and understand systems and processes from very different domains with the same set of fundamental concepts. It was constituted as a field in the *Macy conferences* organized by Warren McCullough from 1946 to 1953, who invited the leading scientists of the times from fields like anthropology, mathematics, neurology, psychiatry, biophysics and others[18]. The term *circular causality* in biological and technical systems refers to phenomena that occur when parts of a system influence each other such that linear causal chains form loops, requiring the new concept of *feedback*. At the time, this idea was in the air in many fields. The name *cybernetics* was adopted from the eponymous book by Norbert Wiener,[19] when Heinz von Foerster proposed it as the ideal name for the conference series, and it later became the common label for this meta-discipline.

[18] Pias, Claus (2003): "Cybernetics|Kybernetik. The Macy-Conferences 1946-1953. Bd. 1 Transactions/Protokolle." Diaphanes. Contains a full reprint of the proceedings of the later Macy conferences and added documentation.

[19] Wiener, N. (1948). *Cybernetics: Control and communication in the animal and the machine.* New York: Wiley.

In the first phase of cybernetics (later called *first order cybernetics*), one assumed that observers can study the causal pathways in systems from the outside, deduce how to influence the system in question, and then control it such that it reaches the desired state. Typical states are stable dynamic balance (homeostasis), cyclic balance (periodic oscillation), and aperiodic behavior (chaos). This concept was quickly adopted by military, political and economic leadership, as it seemed to promise technocratic control of societies worldwide.

Second order cybernetics (or *cybernetics of cybernetics*, as Margaret Mead put it)[20] emerged from 1965 on, and here cyberneticians consider the observer an essential part of the system who always influences the system from the inside. This view foregoes classical notions of scientific objectivity (which were criticized from other perspectives at the time as well, e.g. as constructions of power and control),

[20] Mead, M. (1968). Cybernetics of cybernetics. In *Purposive systems (pp. 1-11)*. Spartan Books. Online at: http://www.univie.ac.at/constructivism/archive/fulltexts/2634.html

and replaces it with the now commonsense idea that one understands a system much better by interacting with it, and thus encountering its behavioral repertoire actively.

[21] Maturana, Humberto R., and Francisco J. Varela (1991, 1st ed. 1973). *Autopoiesis and cognition: The realization of the living*, Biosystems, 5(4), 187-196, Springer, New York.

The concept of *Autopoiesis[21]* was formulated by Maturana and Varela as a "necessary and sufficient" characterization of how living systems organize themselves, such that they continuously recreate their constituent parts, and thus achieve relative independence (decoupling) from their environment. The concept has later been adapted for many other contexts, with varying precision and success.

[22] cf. the WISDOM book series by echoraum editions, online at http://www.echoraum.at/edition/wisdomechoraum.htm

[23] See his reprinted article on Hylozoism in this book, and Pickering, A. (2010). *The cybernetic brain: Sketches of another future*. University of Chicago Press.

Both waves of cybernetics were adopted quickly in many disciplines, and over time got absorbed into the invisibility of standard practice in each field. After a phase of buzzword fatigue, its history has been studied more deeply again since the 1990s by the Heinz von Förster archive in Vienna, in particular by Albert Müller und Karl Müller[22], and Andrew Pickering, who focuses on what he considers the »nonModern« ideas of the early British cyberneticians[23].

[24] von Glasersfeld, Ernst (1984). "An introduction to radical constructivism." In: *The invented reality*, 17-40. von Glasersfeld, Ernst (1995). "Radical Constructivism: A Way of Knowing and Learning." *Studies in Mathematics Education Series: 6.* Falmer Press, Taylor & Francis Inc.

[25] von Foerster, Heinz, and von Glasersfeld, Ernst (1999). *Wie wir uns erfinden. Eine Autobiografie des radikalen Konstruktivismus. (How we invent ourselves. An Autobiography of Radical Constructivism.)* Heidelberg (Carl-Auer-Systeme). This is a wonderful dialogue between the two, on the parallels between and entanglements within their fascinating intellectual and personal biographies.

Radical constructivism is an epistemological position developed mainly by Ernst von Glasersfeld which corresponds closely to cybernetic insights by Heinz von Foerster[24][25]. It has a very pragmatic way of dealing with the epistemic uncertainty underlying all human knowledge. Rather than assuming that human knowledge (such as Western science) will eventually discover the real laws as they exist in nature independently of us, it proposes a consistent form of epistemic humility:

1. We can only attempt to understand the world by observing it and interacting with it, we can not attain privileged direct access to it. Any observations will be filtered by the perceptual abilities and limitations of the observer(s).

2. The best we can achieve in understanding aspects of the observed world is a reasonably good fit between specific observations and generalized descriptions of them ("laws"), which may allow reasonably accurate predictions.

3. Mental models of the world are constrained by human mental abilities and the course of their development (Glasersfeld was greatly influenced by the writings of Jean Piaget).

Causality in artistic practice

> "If there is a sense of reality, and no one will doubt that it has a right to exist, then there must also be something one can call the sense of possibility. Someone who has it does not say, for example: Here this or that has happened, will happen, must happen; but he invents: Here [this or that] might, could or should happen; and if one explains to him that something is the way it is, then he thinks: Well, it could likely be different. Thus one could even define the sense of possibility as the ability to think everything that might as well be, and not to consider that which is any more important than that which is not."
>
> *Robert Musil, Der Mann ohne Eigenschaften*[26]

[26] *Translation AdC.*

Musil's definition from the early 20th century is echoed by political economist Albert Hirschman, who called his strategies for breaking out of both left and right dogmas confining development economics in the 1970s as his "possibilism."[27] In a diary entry around that time, he asks: "Aren't we interested in what is (barely) possible, rather than what is probable?"[28]

[27] Hirschman (1973).

[28] Adelman (2013), p. XII

Models, Worlds, Making

Mental models of the world need not be large and complex; the point of scientific models is often to make them as simple as possible, while still maintaining the aspects of interest. Especially when these models are cast into the form of computer simulations, one can verify that the model captures the essence of the world being modeled, when the behaviors of interest are still present for observation and interaction in the running model. Rheinberger describes experimental setups in science in related ways: endless tuning of the details of a setup allows identifying which circumstances are fully understood, and can be fully controlled.[29] This allows other aspects to turn the specific setup into a *surprise generator* which actually destabilizes the current working understanding of a process, and thus prepares for truly new, surprising and deep insights.

[29] Rheinberger, Hans-Jörg. "Toward a history of epistemic things: Synthesizing proteins in the test tube". Stanford University Press, 1997.

In the arts context, detailed models of worlds will obviously provide rich experience of their content for visitors. However, this richness may detract from the clarity of the aspects of specific interest to the artist. Smaller, more reduced worlds allow freer experimentation with their working mechanisms, and by focusing on inventing small sets of rules, artists may actually achieve deeper surprise and challenge for the visitors. In cybernetic language, aiming at nontriviality, and focusing on the subtle or manifest aspects in which even a very simple world differs from the real world seems artistically highly desirable.

Invention of works and worlds

Let us briefly look at some ideal-types of artistic working processes, in simplified form, and with examples from music as one particular kind of time-based art. All of them may apply for pieces resulting in some final material form, such as fixed media, and in running processes, which may or may not provide options for intervention by performers or audience members.

Invention of all detail: This is the traditional stereotype of the artistic process. Here, art works are the result of long accumulating series of decisions, which determine all details present in the final version of the finished piece. In music, this might be a score which uses precise notations to indicate what sounds/notes should be played by which musicians within the duration of the piece. In pieces following known styles, much of the detail can be created quickly based on rules implicit in the given style. Very often, plans exist that determine structural elements, generate preliminary orders of the materials to be used, and can be expanded in sketches that are worked out toward a final form.

Invention of process that generates fine structure: Rather than deciding every detail individually, a process is devised that will generate more or less detailed raw material for the piece. These can be harmonic structures, rhythmic processes, distributions of parameter values in time, etc.; such raw material can then be sculpted into final versions of sections of the piece. In some textbook examples of evolutionary art, the artist (or the audience) selects preferred instances of the same artwork family which are then used to evolve the more or less final forms.[30]

[30] Whitelaw, Mitchell (2004). *Metacreation: Art and Artifical Life*. MIT Press.

Invention of processes that constitute a piece: the artist designs a running process that exhibits interesting observable behavior. Depending on its specifics, this process may be closed to the outside world and run completely autonomously, only requiring a decision to start it.

It might also be a process that is open to influence from the world, and this may come from observation of the world context (sensors measuring any parameters of the world, and informing the system about them), from specific interaction by informed specialists (performers playing an interactive piece), from audiences reacting to their experience of the piece, and other forms of influence. In the former case, artists may decide to create definitive rendered versions as the final artwork. For the latter, presenting the running process for immediate experience seems the more desirable final result; recordings of performances (with or without external influence) will more likely only have documentary character.

To conclude, one rather open definition of a "world" in artistic contexts would be any process that unfolds in time, which is observable, and allows observers to form hypotheses about it; likely one of the simplest forms of hypothesis-forming by audiences is predicting the future by guessing what will happen next. Already in conventional music settings, there is a nexus between perceived causality, intention and perception: when listening to an unfolding performance of music or audiovisual art, part of the enjoyment for audiences can be guessing what will happen next and reasoning about the artist's decision processes.

Systems with mechanisms modeled fully on the real world are often rather predictable, and observers may lose interest quickly once they feel they have understood what the observed system does. Systems may be more intriguing to observe when their internal logic deviates from simple assumptions. Especially in systems inviting interaction, surprises change the hypotheses-forming game to one of inferring aspects of the underlying world logic, i.e. its causal mechanisms.

Cybernetics and causality in music

Many artists have found and are finding inspiration for their work in cybernetic and system-theoretical thought models. Louis and Bebe Barron built electronic circuits in the 1950s that influence each other in ways that create surprisingly complex behaviors on multiple timescales. They created the first fully electronic soundtrack in film history with them for *Forbidden Planet* (1956). Their approach was inspired by Norbert Wiener's book *Cybernetics*[31].

[31] Wiener (1948)

David Tudor realised many projects by building large assemblages of modular electronic circuits in soap boxes, connecting them, and playing their paths of influence intuitively. The declared aesthetic intention of letting the inner life of the circuits express itself could be put in cybernetic terms as making their nontrivial behavior observable, or in today's terminology, ascribing agency to them.

A number of pieces by Agostino di Scipio constitute complex ecosystems[32], in which acoustic paths and digital sound processing form feedback paths in rich variety. Rob Hordijk builds electronic instruments like the *Blippoo Box*, which he designs as a kind of well-tempered chaotic system.[33] Peter Blasser (cf. his article on *Plumbutter* in this book) builds devices that go far beyond musical instruments: they create such complex variation on their own that I would rather consider them meta-compositions which one can play by influencing their inner states. He also describes his creations in poetic vocabulary that far exceeds engineering language: "If you start not from 'knowledge', but at instead at any random and humble point within the aaji [i.e. assemblage of raw electronics], you will see more than just arrows pointing in and out, but directionless flows, the stuff of simultaneity. No matter how hard you try, you cannot make an assemblage into male (only giving) or female (only receiving)."[34]

[32] Solomos, Makis. 2014. "Agostino Di Scipio: Audible Ecosystems." *Contemporary Music Review* 33 (1). Routledge: 2–3.

[33] Hordijk, Rob. "The Blippoo Box: A chaotic electronic music instrument, bent by design." *Leonardo Music Journal* 19 (2009): 35-43.

[34] Blasser, Peter (online) *philosphical paperz*. http://ciat-lonbarde.net/fyrall/paperz/index.html, accessed 20/07/2017.

George Lewis's project *Voyager*[35] is much closer to instrumental music performance. He has been developing a computer system that behaves like an idiosyncratic improvising musician over decades. It is not intended to be an accompanist only, but can play autonomously as well, and will often demonstrate initiative on its own terms.

[35] Lewis, George E. (2006) "Too many notes: Computers, complexity and culture in voyager." Leonardo Music Journal 21 (2006): 19-23.

Reversing Pendulum Music (2010)

Reversing Pendulum Music is a generative performance piece I conceived for the Wave Field Synthesis System at TU Berlin. This system uses 800+ loudspeakers to reconstruct the overlapping sound radiation fields as generated by physical sound sources in space.[36]

[36] Baalman, Marije (2008), *On Wave Field Synthesis and electro-acoustic music, with a particular focus on the reproduction of arbitrarily shaped sound sources.* Ph.D. thesis, TU Berlin, Germany.

8 microphones listen to the sound in the hall, and the sounds they hear are played into the room by 8 virtual sound sources which swing though the room, their movements being controlled from a virtual gravitation system.

The resulting latent feedback is influenced by a number of environment imponderabilities: microphone placement and settings; electrical noise floors and frequency responses of all equipment components; other peculiarities of the WFS system in its current software and hardware incarnation; and noise sources in the room and building. The performer can influence parameters of the gravitational system like gravity and friction, additional delay times, limiting and basic filtering. 10-12 parameter constellations were found in the rehearsals and stored as presets, and they were used as points of convergence in the flow of the piece.

The piece quotes the title of "Pendulum Music" by Steve Reich, and plays with inverting several aspects of its model. Pendulum music follows classic experimental setup: Several microphones are suspended from their cables so they can swing over loudspeakers lying on the floor. The microphone sound is played through the speakers, so when close enough, feedback will occur. Performers start the process by letting go of the microphones in the defined starting positions; the piece ends when the sound has become static, and the amplifiers are turned off.

In first order cybernetics terms, this is a system showing circular causality (feedback); neutral observers set up a process for presenting its behaviour. By comparison, *Reversing Pendulum Music* uses a second order point of view: the system is a model world with simulated sound sources and gravity; the observer is involved and interacts with the system by changing its meta-parameters such as gravity, friction, etc. creating a second layer of circular causality by listening and being influenced by the sounds generated. An additional layer of simulation comes in when playing the piece on a non-WFS sound system: then the piece can be played through a simplified imitation of the simulation that occurs in the WFS system with simple distance based delay panning, and modeling the "stepping" artifacts the WFS system created when setting position controls.

Varia Zoosystematica Profundorum

(2010, A. de Campo, H. Hoelzl, R. Wieser and many participants)[37]

One enters a tower on top of a hill, goes down a circular staircase inside the tower, and arrives in complete darkness, immersed in a dense, strange soundscape. With a weak LED flashlight, one can barely make out the round walls of a corridor, and slowly moving along by touch, one finds a creature, a giant eye dramatically opening every now and then. Moving on, more and more different alien creatures are encountered; over time, one adapts to the darkness, and after maybe 10 minutes, one can move freely in the dark. From up close, the creatures do very little most of the time; sometimes they burst out in sound, light, motion patterns. When it is calm again, one hears the sounds of neighboring creatures one may have seen already. When these are also silent, one can hear the creatures further away, drenched in reverberation[38].

This is the typical experience visitors had when entering the installation "Varia Zoosystematica Profundorum" as shown in the Grosser Wasserspeicher[39] in Berlin 2010. It is modeled on immersion in the deep sea: light would only be present from (soft) bioluminescent sources, and get absorbed at short range, while sound carries much further, and allows more overall orientation.

The process of creating this installation was inspired and informed by many sources: recent insights in acoustic communication of deep sea creatures; a set of seminars doing related reading and experiments in generative art, and the book *Vampyroteuthis Infernalis* by *zoosystematicien* Louis Bec and philosopher Vilem Flusser[40].

In *Vampyroteuthis infernalis,* Flusser juxtaposes the radically incommensurable world experiences of humans and deep sea octopuses, which created a sense of freedom in the group of participants, a license to create improbable creatures with strange ways of being in their world. Its flight of thought neutralizes the conventions in biology to explain every aspect of animal behaviour as driven by survival, even if that needs complex reasoning; it seems that plenty of counter-examples of animals can plausibly be considered e.g. playing, with all its implications.

[37] this section adapts material from de Campo, Alberto, Hoelzl, Hannes, and Wieser, Renate (2010). "Varia Zoosystematica Profundorum: Modelling deep sea communication collectively." In: *Proceedings of Generative Art Conference GA2010*, Milano, pp 47-61., which is an extended discussion of this project, particularly its collaborative creation process.

[38] The video documentation gives a reasonable impression of this: https://vimeo.com/63974714

[39] This is an empty former water reservoir, which was used for many sound art exhibitions in Berlin. There is a playground on this hill-top, and so many children became curious and went to see the creatures, and later returned with their friends and parents.

[40] Flusser, Vilém, and Louis Bec (1987). *Vampyroteuthis Infernalis: eine Abhandlung samt Befund des Institut scientifique de recherche paranaturaliste.* European Photography. And in English: Flusser, Vilém, and Louis Bec (2012). "Vampyroteuthis Infernalis: A Treatise, with a Report by the Institut Scientifique de Recherche Paranaturaliste."

Figure 2: Paulantinautius divinatio are deep sea octopuses belonging to the family of Bathypolypus arcticus. They normally live in depths from 1900m and below. Their most famous specimen was brought back to its original environment after playing the widely publicised role of Paul the" world championship oracle". After *Paul* died on October, 26th, 2010, *Paulantinautius* is the only descendant being alive. (modeled by Bernhard Bauch)

The major reference for the piece in cybernetic arts is Gordon Pask's installation *Colloquy of mobiles*, his groundbreaking contribution to the *Cybernetic Serendipity* exhibition in London [41]. *Colloquy* modeled quite complex communication behavior between its agents, suspended creatures producing light and sound signals, and physical movement, for the light signals required alignment to reach the corresponding receptors. Its behavior patterns followed a tongue-in-cheek biological model - there were female and male objects with "drives" - and it invited the audience to intervene, e.g. by whistling or additional light signals.

[41] Reichardt, Jasia (1968). *Cybernetic Serendipity*, Studio International special issue. 1968.

In *Varia*, the group decided early to forgo "natural" activities like search for food, avoiding enemies, mating etc, and instead concentrated on symbolic communication, with a large community of creatures listening intently, and only rarely sending. They all have the same kind of brain, while having radically different bodies and modes of expression, and only communicate by telepathic means - a radio chip. This initial choice of constraints led to simple behavioral rules: the creatures listen for and receive small messages from each other; they assemble these slowly into larger messages, which they occasionally express in sound, bioluminescent-like light, and/or movement.

The unusually collaborative work process, creating a continuous stream of ideas jointly, was a deep learning experience for all participants. It also created an unusual sense of freedom when designing causal mechanisms for our world, like the style of symbolic communication. A model of inner energy accumulated by listening and spent in expressing, and individual preferences for certain combinations of letters, led to long term drifts in "emotional atmosphere": peaceful, sparse moods would slowly build up to dense soundscapes, occasionally bursting into short episodes of what seemed to be joyful expression by many creatures simultaneously. Within this overall framework, the participants made radically different individual creatures that would form this community.

On a personal note, I find the special social situation we created in this creative process became as much an art work as the installation itself, and I would not want to choose which of the two is more important and satisfying to me. While taking turns guarding the installation, the participants would describe the overall concept, the details of the creature they had created themselves, and those by others with absolutely equal enthusiasm to the visitors. I take that as one more indication that the working process and the results gave them a deep sense of shared authorship.

The Ways Things May Go

(2012, A. de Campo, H. Hoelzl & many participants)

This work is a meditation on invented causalities in a networked world.[42][43] It consists of multiple nodes, which are connected by a causal-topological network. Every participant constructs a node, which is typically a physical process that forces a random decision between at least two alternative outcomes; depending on the outcome, one of the predefined successor nodes is set in motion.

For example, process A (SinPong, figure 3a) can be a machine throwing orange and white pingpong balls in the air with a bass loudspeaker; when a ball falls into the outside runway, a camera determines its colour. When the ball is white, process B is triggered, when red, process C. Process B (HamsterGestüt, figure 3b) can be a group of toy hamsters whose collisions produce three possible outcomes, and process C can be a sound-activated pendulum, which at some point closes one of several possible contacts. Such a network creates an infinitely continuing (pseudo-)causal chain reaction, which can always take new, different sequence paths through the same repertoire of processes.

The topology of the causal connections is defined in the connecting software, and is deliberately set to a new constellation for every calendar day. Figure 4 shows the running visualisation of the running chain. All processes are represented by name, and each one points to each possible successor with a slim arrow. One can see the entire causal topology as valid for that day. The currently active process, e.g. SpeakerPendulum is shown in color and with bigger successor arrows, so one can tell that FotoTV, MusicSearch oder Pollock-O-Mat could be activated next, depending on which end state SpeakerPendulum comes to rest on.

The obvious point of reference for this piece is the film *The Way Things Go* by the Swiss artist duo Fischli/Weiss (1987), in which thirty minutes pass with one physical or chemical process triggering the next;

[42] de Campo, Alberto, Hoelzl, Hannes et al, *The Ways Things May Go*, installation as shown at ctm Berlin (2013). Video documentation is available at: https://vimeo.com/61503466

[43] Lennart, Ulrich *The Ways Things May Go* contributions produced at Arts Academy Bremen (2013). Video documentation is available at: https://vimeo.com/59601090

Figure 3a: *SinPong* by Tobias Purfürst. (photo © Purfürst)

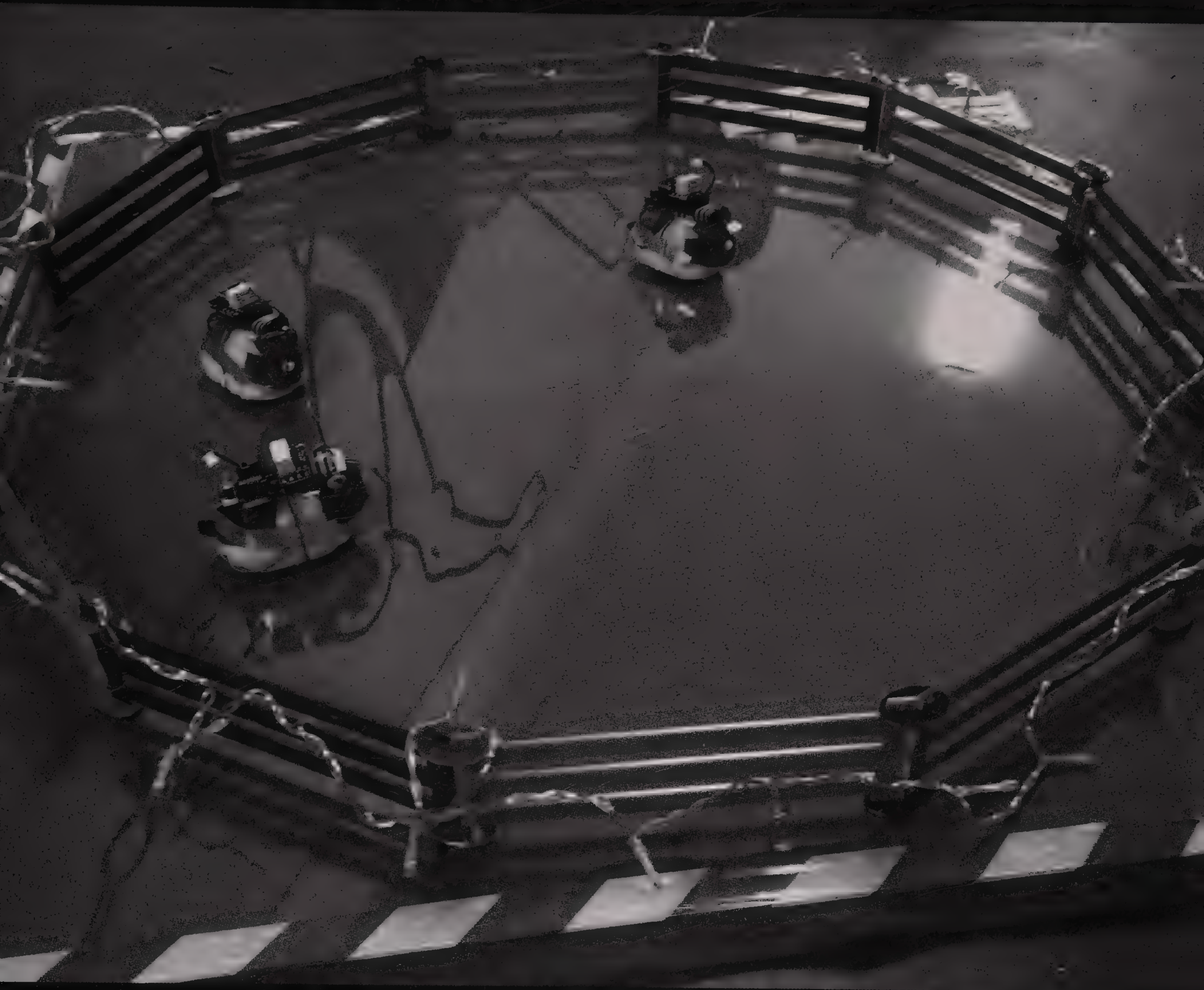


Figure 3b: *HamsterGestüt* (hamster stud farm) by Alberto de Campo (photo © de Campo)

as a viewer, one is fascinated and waits for the next turn of events, at times one sees an obvious transition coming, at others, one is completely surprised by how the transition happens. Czech/Jewish/Brazilian philosopher Vilem Flusser reviewed the film for a journal, intriguingly arguing that the films simultaneously posits three interpretations of the micro-world it shows: First, that the world is pre-programmed by divine order; second, that the world is a mindless, machinic chain of trivial causes and effects; and third, that the world meanders along by sheer coincidences forming slings, so that completely unexpected things could happen at any time. In a textual description of a world, these notions would conflict; Flusser observes that in this film, they do not, and he finds the film "breathtaking" in that it proves one of his favorite hypotheses at them time, namely that one can philosophize in images.[44]

[44] Flusser, Vilem (1991). Review of "Der Lauf der Dinge" by Fischli/Weiss, *European Photography*, No 45, 1991, pp 46-48.

Linear film obviously lends itself to staging one perfect run of a causal chain, and Fischli/Weiss do this spectacularly well. Choosing the form of an installation of electro-mechanical nodes opens different options: a network of interdependent processes which force-produce random decisions in the physical world. TWTMG is a model of a pseudo-causal world with an extremely reduced notion of invented causality. Every 'cause' has a fully known set of two or more 'effects', and every activated 'effect' becomes the next single 'cause'. All causal links are set deliberately, and the entire communication protocol consists only of a 'start' signal being passed from one node to the next, and a 'started' confirmation signal. As an observer, one may be surprised by the fragility of some of the individual processes, and be curious what happens if the process does not reach a valid end result. Also, one may wonder which circumstances influence the outcome of the currently active process, and hope that its possible results are all roughly equally probable, since otherwise the overall network may get stuck in rather short repetitive causal loops. Even with such a reduction to the bare minimum, causality feels quite unpredictable, if not arbitrary here. For me, this makes for interesting comparisons to scientific model making in domains like economics.

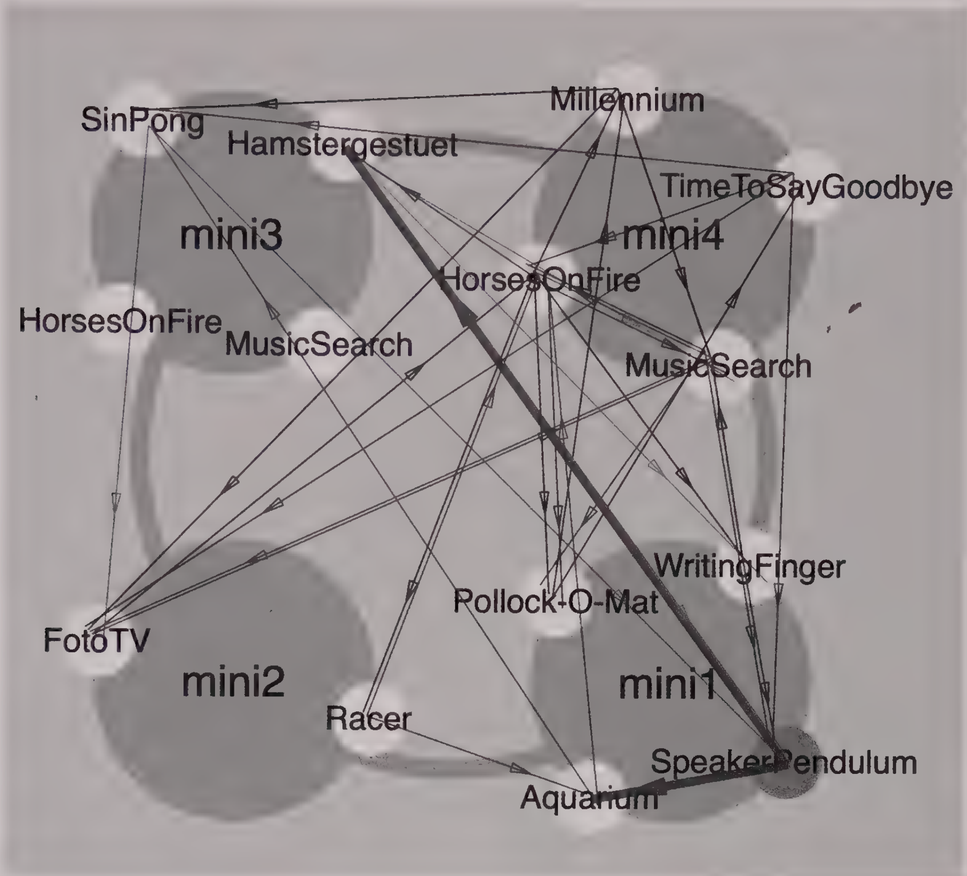


Figure 4: Topology of causal pathways for a given day in The Ways Things May Go.

MetaControl, Influx, Modality

MetaControl is an attempt to rethink human-designed causality in the context of musical instrument design in ways orthogonal to standard practice in the field, as it manifests itself in conferences like NIME[45]. The fundamental difference is foregoing the idea of "control" and moving toward a more dynamic process of learning to deal with surprise in artistically desirable ways, by exerting influence in ways one can not (and need not) fully account for analytically. The group Trio Brachiale has recently discussed its artistic aims and working experience with these approaches in depth[46].

The largely consensual model for NIMEs assumes that a NIME consists of a human player who expresses her intentions in movement,

[45] "New Instruments/Interfaces for Musical Expression", http://www.nime.org/

[46]Hildebrand Marques Lopes, Dominik , Hoelzl, Hannes, and de Campo, Alberto (2017). "Three Flavors of Post-Instrumentalities: The Musical Practices of, and a Many-Festo by Trio Brachiale." In: *Musical Instruments in the 21st Century* (pp. 335-360). Springer Singapore.

which sensors convert to digital control signals. The sound is typically produced by a generative process, whose parameters are informed by a more or less complex mapping of movement-based signals to the process parameters (see figure 5, below). In analogy to traditional instrument building, NIME designers tend to refine both the sound processes and the mappings further and further in search of an ideal final well-tuned state, which allows musicians to develop 'virtuosity' on the new instrument. This notion of the optimized ideal mapping resembles the quest for detail improvements in mechano-acoustic instruments, where the range of design choices is strongly constrained by the laws of mechanical physics. In the interest of attaining complete control of such performance instruments, musicians tend to choose simple one-to-one mappings that are easy to understand and remember–for example, slider1 controls amplitude, and slider2 controls filter frequency of sound X.

Software is rightfully called soft, as it can be changed at any time when there is a new idea of how the setup could be different. Especially the mappings as mediating layer between human and process are the part of the model that is technically the easiest to change, where, given some risk affinity, one can achieve many surprising moments. The slogan 'lose control, gain influence'[47] sharpens the contrast between conventional logic of power ('command and control' in military parlance) and models of networks of agents influencing each other, where observers find the option attractive to intervene by experimental interaction, learning quickly what the current possibility spaces are.

[47] de Campo (2014)

Modality[48] is a collaborative software project that promotes the idea of highly modal interfaces, i.e. interfaces where a relatively small set of control elements can be used to play with a comparatively large number of processes in very flexible ways, changing the meanings and functions of potentially every interface element in the flow of performance. This allows performers access to much larger possibility spaces quite fluidly, allowing fast changes of direction as they are often desirable in open improvisation contexts.

[48] Modality Team (2015): http://modality.bek.no. accessed 20/05/2016

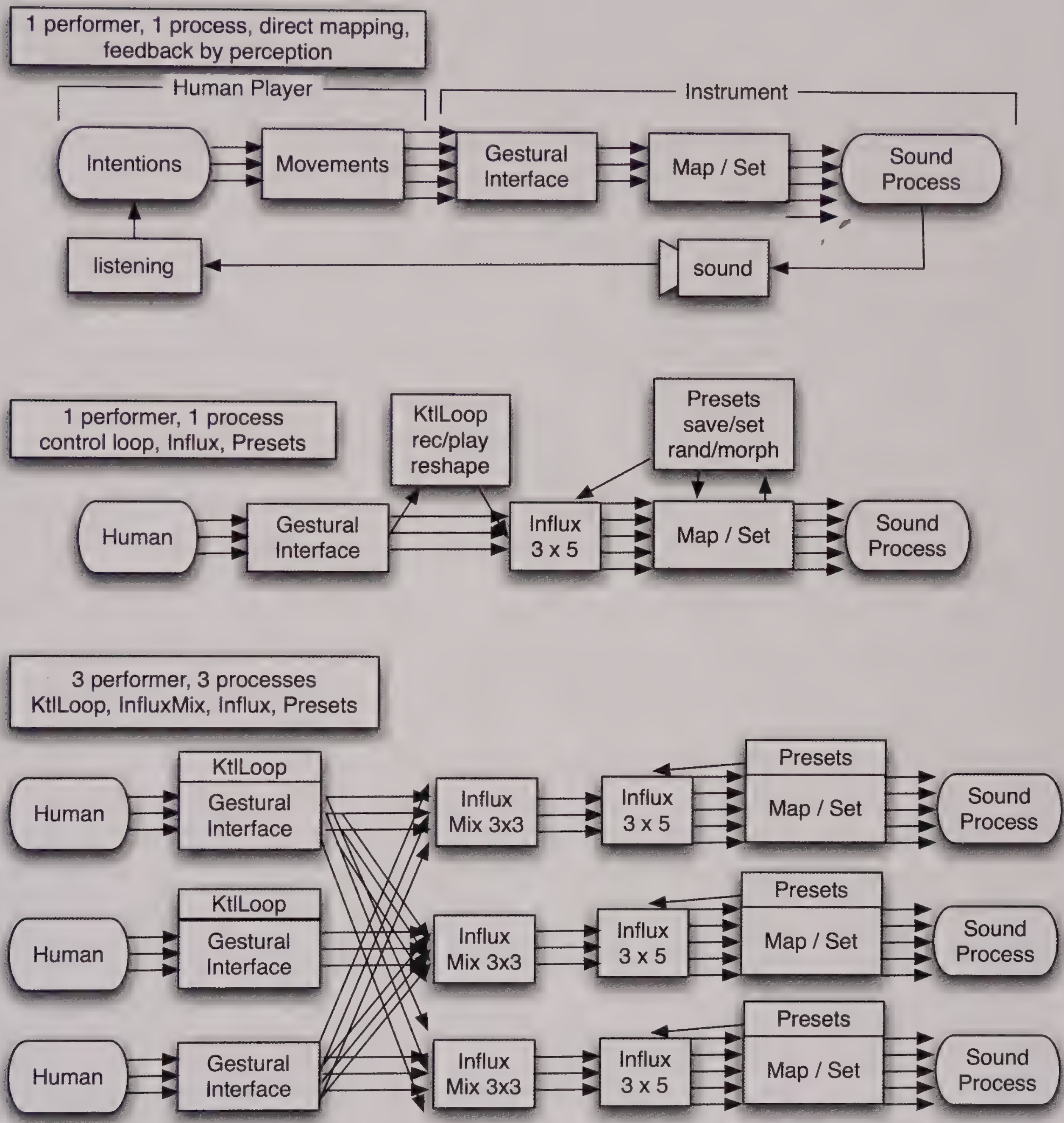


Figure 5: Models from control topologies, from conventional digital to networks of influences adding more metacontrol elements in each iteration.

Influx is a software library offering tools for exploring such concepts of non-analytical influence on running processes. One can begin with conventional mappings where as usual, each interface element controls well-chosen specific process parameters. Mappings can then be gradually »entangled«, such that every control element influences other process parameters as well by small random amounts; »disentangling« then is morphing the current complex mapping toward a known simpler mapping. While the sound producing process itself, which is a defining part of an "instrument" or setup, remains unchanged, different mappings will make different regions in the (mathematically and practically huge) multidimensional parameter possibility space accessible, and experience shows that even very familiar processes offer new sonic options when influenced via such entangled mappings.

Influx supports several ways of creating and collecting further performance material: Storing specific points in parameter space as presets while playing, which can be an Ariadne's thread of anchors for future exploration of each stored region; recording movement figures as *control loops* which can be accessed and modified, from repeating loops, reversing, inverting, rescaling in motion size and time. All of these can also accumulate over multiple performances, forming a kind of machine memory of the longer-term experience of performing with a given process or setup.

Furthermore, *Influx* makes it easy for one source to influence multiple processes simultaneously, such that the same gestures have effect in potentially very different sonic spaces. Finally, multiple players can influence the same process simultaneously, so multiple gestures inform the same sonic space in complex ways.

Conclusions and Outlook

In everyday experience, processes with apparently simple causal mechanisms turn out to be surrounded by a context of layers of less and less obvious, and more and more improbable influences. In the practice of Worldmaking, these fundamental uncertainties around all causalities may well serve to open many creative options, by sharpening artists' awareness of more remote areas of the possibility spaces they explore, and by encouraging them to play with nontrivial mechanisms potentially capable of surprising the creators themselves.

The meta-control strategies begun with the *Influx* library are good examples: While technically simple, these special forms of moving from control causality to polyphonies of influences open many options on a variety of conceptual layers: choosing fine-grained degrees of determinacy; risking being surprised by nontrivial behavior even of a performance setup one knows really well; sharing moments of authorship uncertainty where none of the players can really know who is responsible for which aspect of the jointly played sound world. They have been put to experimental use in the last three years by the members of Trio Brachiale, Kairos Theory Trio, The Society for Nontrivial Pursuits, and researchers, student participants and guests in the 3dmin project (http://3dmin.org). Many of these informally report a sense of exciting new perspectives and possibilities for their artistic practice.

Some strategies toward more complex networks of human and machine actors can be mapped out already; basic machine self-awareness would be my top priority here. As Braitenberg's "law of uphill analysis and downhill synthesis" states, simple rules for behavioral synthesis very often lead to a repertoire of behavior that exceeds all planning, and conversely, "when we analyze a mechanism, we tend to overestimate its complexity. In the uphill process of analysis, a given degree of complexity offers more resistance to the workings of our mind than it would if encountered downhill, in the process of invention."[49] Thus, making longer-term experience - recorded states, behavior sequences, performance histories - of systems automatically available and accessible to them should allow the systems basic forms of learning about themselves. Equipping machines with basic perceptual abilities - forms of machine listening and visual perception of the output created for human senses and its context - may create behavior that will resemble self-perception and self-observation for human agents engaging with them.

[49] Braitenberg, Valentino (1986). *Vehicles: Experiments in synthetic psychology.* MIT Press.

An Essay on Worldmaking in Plumbutter

From: http://ciat-lonbarde.net/plumbutter/
(text formatted as a facebook post)

Peter Blasser

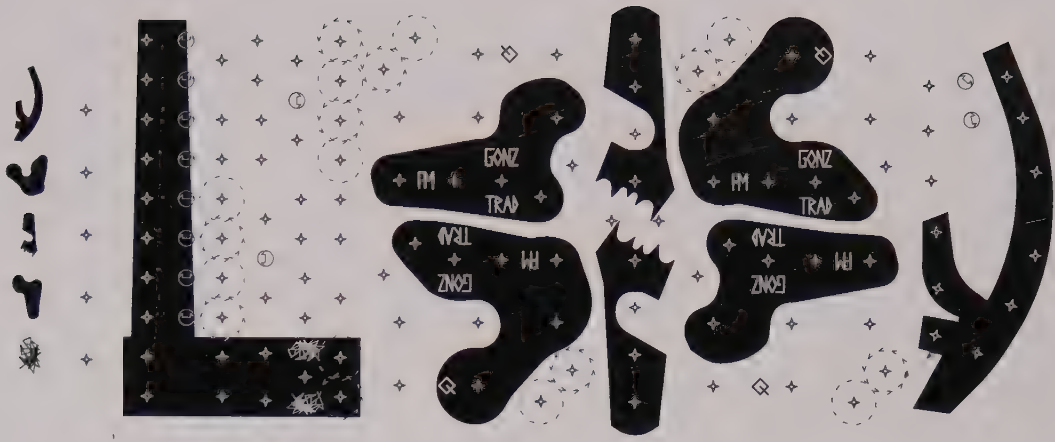


Figure 1. Psycho-geographical map of *Plumbutter*, a gradient from urban to rural.

My name is Plumbutter. My face is a psycho-geographical map of the cities of Baltimore and Cleveland. I am a drum-machine, but let me tell you I am more than that, for I also am a "drama machine". Thus there exists in me, a dialectic between drum and drama, like cops and gangsters, male versus female, or rural versus urban. You can see my wild spaces are represented by a deer-horn, and my downtown by a factory, and in between, a vast swath of suburban developments. It is a gradient of these three areas- urban, suburban, and rural- that informs my electronic synthesis.

Urban, in me, represents a strong sense of rhythm, churned out of machines powered by transformers and electricity which comes from an incinerator, a smokestack. You can see the silhouette of this silo on the left. The factories' product is "beats", the pulse of urbanity.

These pulses are connected, patched with wire, to suburban "inputs", to hear them. The beat is there converted into more human-shaped forms, electronic sounds that convey meaning in their resonances. An organo-form matrix of three types of suburban developments: Gong, AV-Dog, and Ultrasound.

Gong represents the palaces of ritual like a gong which signals the entrance of dignitaries, or courses in a special meal. Gong is triggered by an urban beat, but only after pausing for the proper duration of time, and it is the simultaneous action of multiple gongs that creates change-ringing, or hocketing, across a stereo field.

AV-Dog is a complement to Gong in the suburban matrix, and they are both placed together in checkerboard fashion. AV-Dog resonates the urban trigger, like a dancer or a pool of water. Yes, that is more like it - that the urban beat triggers divers who jump into a pool, and create waves there. These waves jostle sonic buoys, which are the output of this development. They show the rate of resonance within the urban product, they are a detector of resonances at the frequencies of human brainwaves.

Ultrasound is wedged in the heart of suburban development. It represents bats, which should be present in a good suburb. They indicate lush foliage, and they eat mosquitoes. And they sing at ultrasonic frequencies, which is what this module is all about- listening to ultrasound.

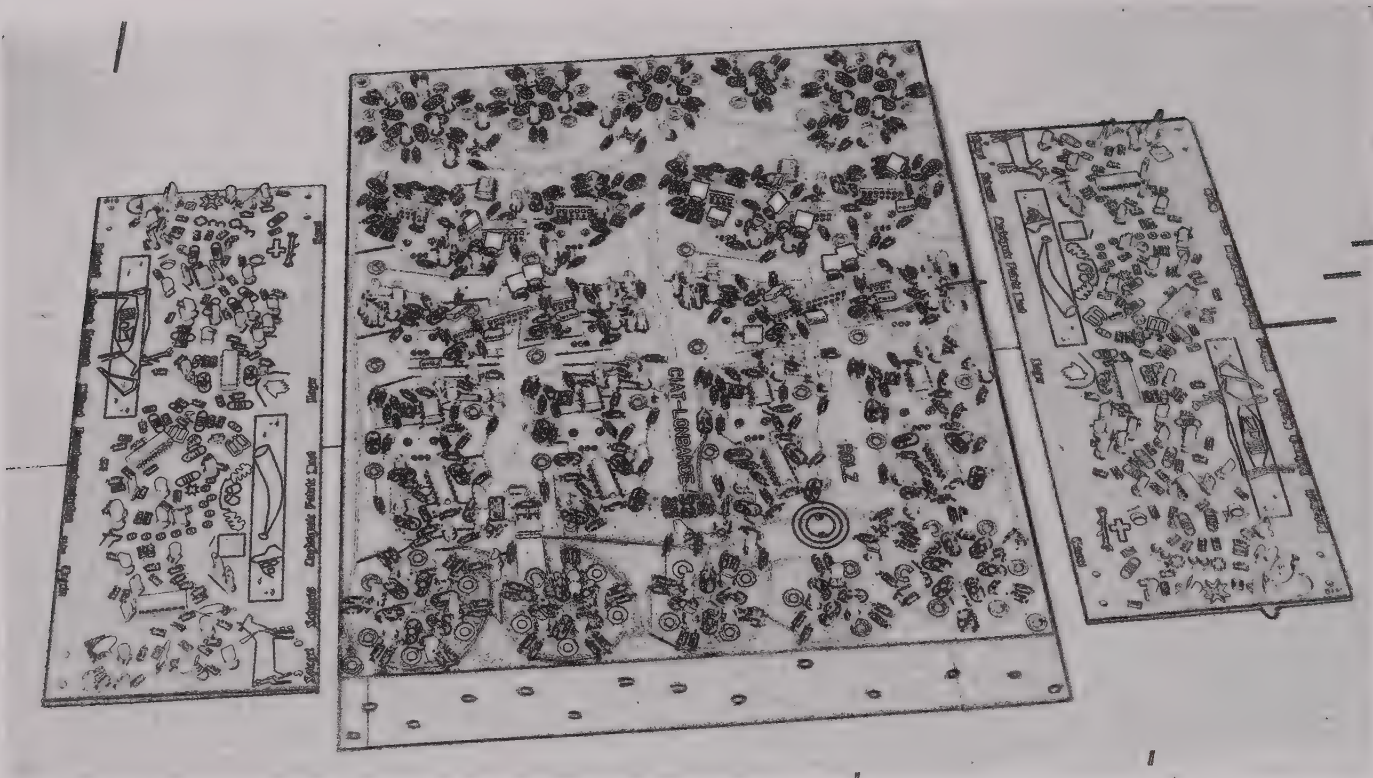


Figure 2. Layout of "Roolz-Gewei."

I am a psycho-geographical map of a utopian city, or perhaps shall we say, a "70s dystopia". For there are flaws everywhere- heavy metals downtown, suburbs which cannot use power sustainably, and prior exploitations in the wilderness. But in general, all is good, as in my "republican" days. And by republican, I mean to say that I once was a republic, like old Rome - a formal grouping of various apparatus onto one "circuit board". My republic was named "Roolz-Gewei", and that is my official name on facebook.

My wildernesses flanked me, on separate circuit boards, and were not integrated. These deerhorn represent invisible radio fields that sense any movement nearby, and through synthesizer organs, bellow and rut. The deerhorn were separate and now are integrated in m'plumbutter. Thus it can be said "a system of interstates (power lines) connects Little Italy to a nuclear reactor in the woods."

A 5-tiered stratification was my republic- Agricultural Cycles, Maritime and Shipping, Ultrasonic Manufacturing Center, Palatial Complices, and Pulsemining. This was my mental map, which contributed to my baroque psycho-geography, along with various utterances from the wilderness- the secret language of the hunter mixed with the sounds of beasts.

This was a baroque time in my development, meaning that the various "twittering machines" that made up my drum machine, they were all tuned to various indigenous frequencies, and there was no common standard. It became a goal to reform this baroque republic into a "Laboratory Roolz-Gewei", and this means the following:

Every resonance and frequency of oscillation is tunable by a laboratory knob with exponential range.

Every resonance or frequency also has an input for modulation, to create more complex dependencies.

To integrate the wilderness into the psycho-map of the city.

I am now called Plumbutter, after my designer whose name is "Petroleum Bottle," and his early encounters with lead (Plumbum) in Cleveland. This name, Plumbutter, is much better than, and encapsulates all of my previous names: Man with the Red Steam (an urban drum beater), Rolz-5 (a drum machine village), Roolz-Gewei (the old republican stratification), and Laboratory Roolz-Gewei (which I am). My name is supremely better than those because it rolls off the tongue well. Think of it as a codename: Plumbutter.

" The Agamemnon Computer"

I orchestrated it with headaches and dry-mouth,
Looking at the Palatial Complex with my alien eyes.
Full moon: organized a great virgins' circle dance,
Gave tambourines and ankle bells to the lunatics,
Covered their nappy thongs and green skin
With columnar tunics.
Told the men to make auloi squeal
So nasal that the whines beat great tones
So as to hew and float the great stones
Now they stand in astrolabe rings,
Where I hunch an old man with no things
Except a skullcap to protect
My bald head from the starz.

-Petroleum Bottle

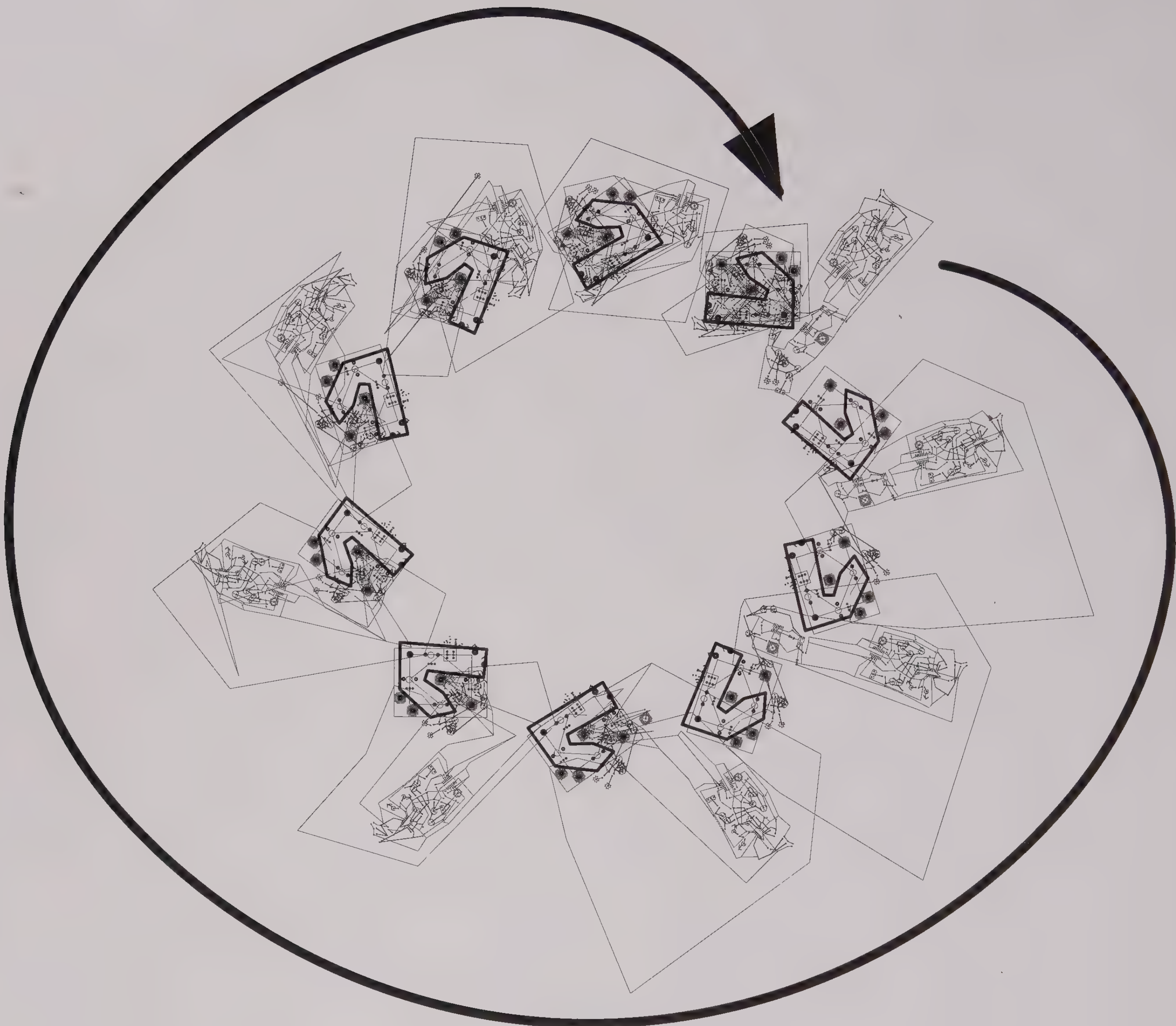


Figure 3. Folding a module to make the *Plumbutter* gambit.

To make my suburban developments, Petroleum Bottle, took my basic twittering machines that were in my republic, and converted them to voltage controlled, laboratory oscillators and resonators. This was done with the help of interstitial paper circuits called AV-Dog Studio and Gongue Studio. The use of paper circuits is very helpful in prototyping complicated building blocks. Then this relatively expansive design was folded down over itself to create my organic suburban footprints. The final module has a sort of pocket in the middle, which is reserved for the special trigger input jack, which is green.

If you want to understand something about 70s suburbs, you must understand industrial color relationships. Prior to the 20th century, color theories derived from natural sources, such as vegetable pigments and looking at rainbows. The mystic thinker, Rudolph Steiner, named seven colors that make up our plane of existence, including "violet" as the highest note of spiritual resonance. But none of these spectra contained the idea of "black" or "white" or "gray" as colors. In the twentieth century, however, we have plastic manufacturing, which can easily create these "colors". Thus the makers of Johnson Banana Jacks provide ten standard hues: Red, Black, White, Green, Orange, Yellow, Brown, Blue, Violet, and Grey. It is thus a central tactic of suburban planning to use all of these colors in the overall plan.

Inputs are cool colors, such as blue, violet, and green. Outputs are hot colors: orange, red, and yellow. Audio outputs are white. Ground is always reserved as the black banana jack. Grey has a special meaning, as noise or another kind of off-beat or rebellious signal. It is a sort of special sauce, designed to cause the drum machine to diverge from normalcy. Brown is a mixture of hot and cool colors (red and green), so it represents special, androgynous nodes, sections of the urban beat that can be "circuit bent" to each other.

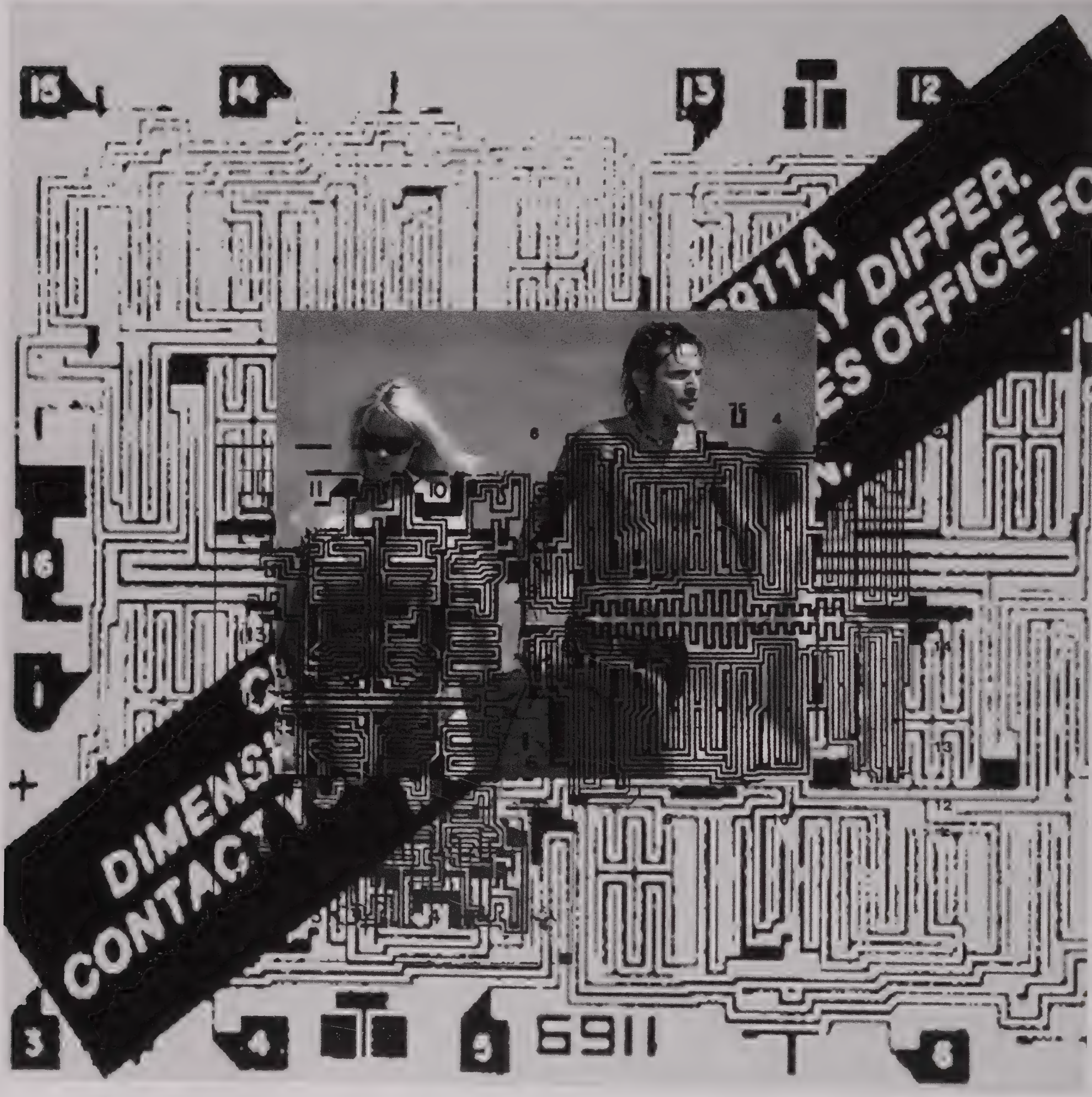


Figure 4. Drum and drama montage.

In "Laboratory Roolz-Gewei schematic," published by Ciat-Lonbarde, much was made of the drum/drama dialectic, and the mediation of the suburbs. The schematics are concluded by a purely symbolic photo montage. I have been using pornographic images, combined with electronic symbols, to convey particular meanings of electronic sounds, such as "analog," "organic," and relationships such as "69".

This montage is about "drum versus drama". At the beach, the drummer Tommy Lee carries a boogey board, and juts his chin, while Pamela Anderson looks inwards with blonde hair unfurled over her breasts and panty-line. Over and behind the coupling, are the black-light doping patterns for three silicon chips used in the drum-machine. 4015 is the ocean in the background, that says "DIMENSIONS MAY DIFFER, CONTACT YOUR SALES OFFICE". 4013, dual flip-flop is Tommy Lee, and 40106 hex trigger as Pamela. They were chosen purely based on form- 40106 as asymmetrical and sensuous; 4013 as tattooed, primal and jutting. This montage helped me create a mental image of the dialectic between drum and drama, and relate it to the silicon chips that function in the machine.

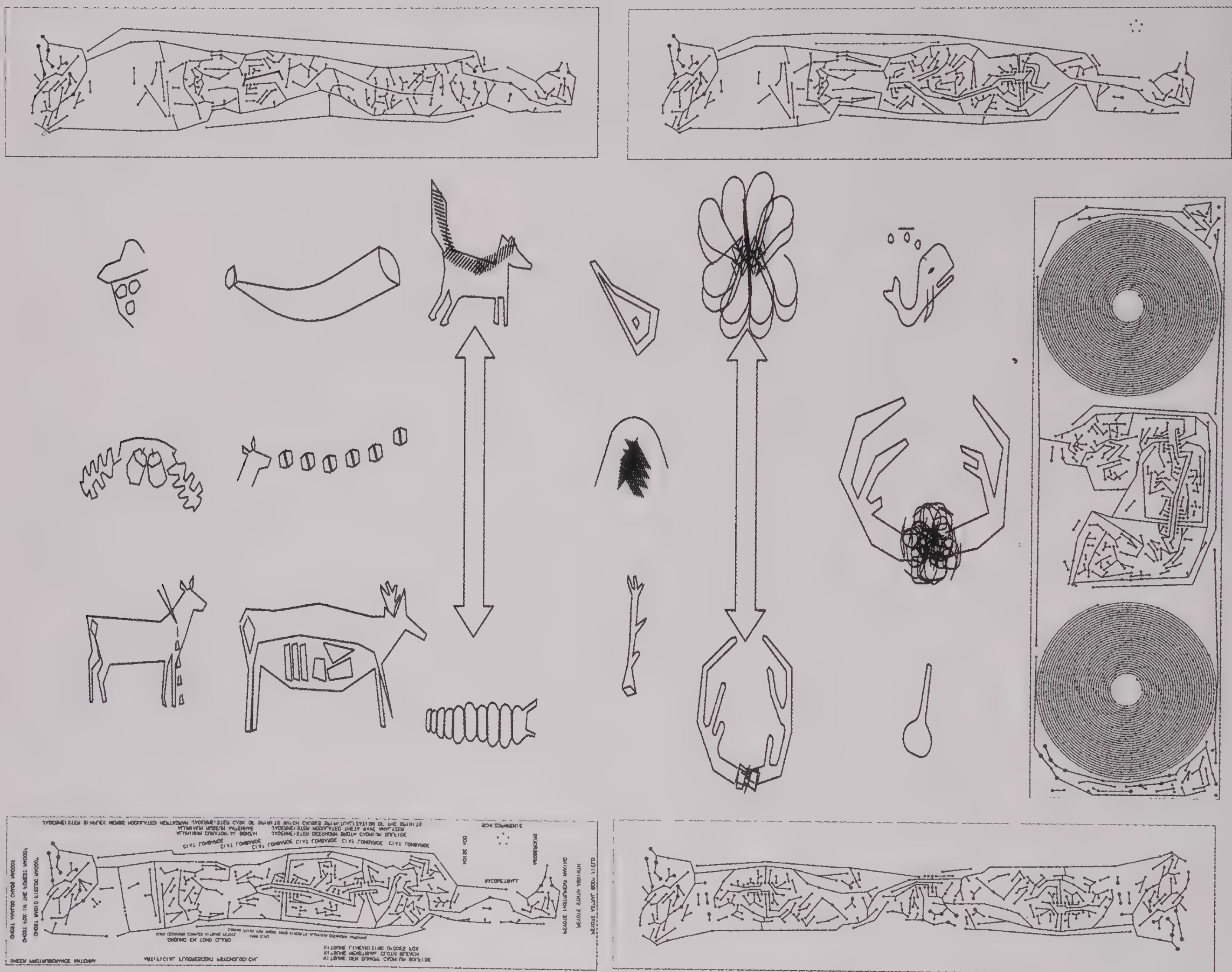


Figure 5. Deerhorn circuit imagery.

The deerhorn module went through several revisions on paper over about five years. When I say "on paper", the circuits were actually printed and built on long paper boards. The circuits were long because of the essential nature of a radio field, which requires spacing from other radio fields. Thus, the deerhorn design has two radio fields, which must be separated by a long space of other circuitry that is not at radio frequency, such as normal analog processes.

Deerhorn began as a simple heterodyne circuit not unlike that of the theremin, and a gestural enveloping circuit that ensured the instrument only sounds with movement, and is silent at stillness. Then I added more apparatus onto this circuit- a frequency to voltage converter derived from the theremin tone, a gestural resonator of this varying voltage, and finally, a phase locked loop circuit which responds most sensitively to the finest movements.

Throughout this development period, the concept of deerhorn was developed in symbols and indeed, in text, on the circuit board. It forms a psycho-geographical map of the hunt for deer: a hunter blows a horn to beckon deer, he searches for mast, the food of deer, and listens for their rutting calls in the woods. He is seeking to bleed a deer and open it up. In the shamanic traditions of North Korea, a fox seen in the woods is quite a bad thing, for it can mean possession and/or mental dissolution. These "foxes" did not appear at all like the English fox, but rather as a sort of maggot/brain floating in midair, semi-transparent as a ghost would be.

The fox is a symbol of the psychological terrors associated with deep woods. The hunter, having succeeded in securing a slab of deer meat, to eat in his cabin in the woods, he also kept the deerhorn. These he will use as symbols of his virility, and to construct strong tools and to use as a finish on musical instruments.

In Mexico, hunting for "deer" literally means to hunt for peyote, a psychedelic cactus. You can see that there is a field of meaning around deer and the woods, that is used as a proxy for other, more sublime concepts. In Germany, a hunter speaks a secret language of false-meanings, intended to fool the forest into yielding deer-prey. These words were printed en masse on the circuit boards and explained with symbols - noise is the internal organs of a deer once it is opened, sweat is the blood which is shed from the deer, organing is the sound of deer in heat and rutting, and noise-syncronization is to imitate these sounds.

And finally, we have the deerhorn rack itself, what can we say about the shape of two deerhorns, arching out from a central plexus of hair and brain? One imagines the tips of the horns have an invisible electric charge that helps the deer sense its way through the woods, and find

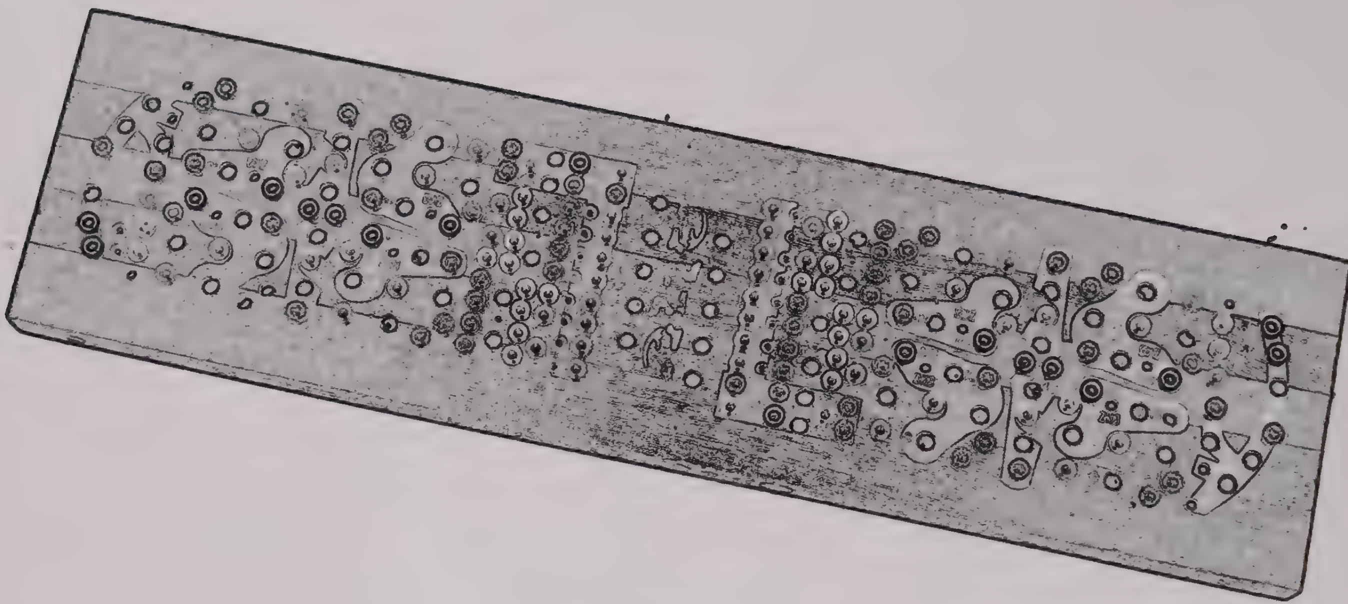


Figure 6. Full dual *Plumbutter.*

other deer. That is the analogy that is directly carried into the deerhorn instrument- sensing movement by modulation of an invisible field around an antenna.

> I often wrestle with words about what I do. I build synthesizers out of wood and circuits, so I spend just as much time with a saw as with the soldering iron. But this term, "build synthesizers", does not cover the conceptual and indeed philosophical processes involved in designing the instruments. In fact, it takes about as much time to design a run of synths as it takes to build them for a few years. And between the *doxis* and *praxis* there is also the wonderful moment of synthesis, when all the planning and prototyping lessons learned are integrated and encased for the first time in a wooden coffin. One does in fact "synthesize a synthesizer". [-Petroleum Bottle]

An example of a problem in synthesynthesis is that of knob orientation. The iconoclastic clockwise means that any user has been trained to expect more in that direction. Wanting more bass, intuitively turn it up clockwise. Wanting a higher frequency, turn it up clockwise. You can see that a synthesynthesist must be wary of the handedness of controls.

In the Plumbutter, all knobs work in this clockwise direction - you can turn up the speed, or q, or frequency, by turning the knob clockwise. Plumbutter is a map of a city, starting from the inside and going out, so to fully traverse the city, you need a dual plumbutter. And a dual plumbutter can only be constructed by rotating by degrees, keeping the factories in the middle and the deerhorns on the outside. So one is rotated, but its knobs still work in the typical clockwise-more manner.

This synthesynthesis topic is called "boustrophedon" after the Ancient Greek method of writing on parchment, "as the cow turns the field". In ancient times, it was not known which direction to write, from left or right, so they did both. Instead of picking up the pen at the end of the line, they just wrote backwards on the next line, thinking this to be more efficient. On the Plumbutter, the vector in to the city, when it becomes a vector out, the modules are read backwards.

Within the suburban modules there is a nested boustrophedon, as the modules rotate around an invisible point, and half are upside down. The logic is to propagate a "boustrophedon" type thought-process that would carry over to the macro level, making a dual Plumbutter not so alien in the obverse suburbs. This is so necessary to have the psycho-geography to be consistent- factories must stay in the core, and deerhorn at the periphery, especially since the deerhorn antennae (not seen here) are on the farthest edge of the case.

What a nice unit. I hope that this talk on synthesynthesis topics inspires you to seek them out as a highest priority in your designs, to not think only on the short term but try to envision how things will all fit together in the extended products.

Where my father dealt with water and the lungs and surgery cuts bloody red,

I work in veins of copper laced together with arteries of tin and lead.

My skin is wood, that is good. My father is dead, I eat lead.

He was deputy assistant secretary of defense for health affairs, and a doctor.

I am creator of schematics for frequency modulated triangle oscillators.

-Petroleum Bottle

Art, Surveillance and Metadata

James Coupe

In *The Order of Things*, Michel Foucault outlines four types of similitude, the first of which, *convenientia*, describes things "*which come sufficiently close to one another to be in juxtaposition; their edges touch, their fringes intermingle, the extremity of the one also denotes the beginning of the other*".[1] Such things complement each other in some way, and share a resemblance borne of juxtaposition and association. Another genre is *sympathy* - things that are sympathetic to each other have something in common that attracts them together, and is the opposite of objects that do not go together at all, which would instead display antipathy. Foucault states that these relationships are not necessarily obvious based on external appearance – in other words they are not purely visible forms of resemblance, but rely on commonalities that are hidden, a situation that "*reverses the relation of the visible to the invisible*".[2] He sees a need for objects to include external 'signatures' that allow us to uncover their hidden qualities.

[1] Michel Foucault, *The Order of Things* (Vintage, 1973), 18

[2] Ibid., 26

Foucault's separation of the 'obvious' and 'hidden' properties of objects is analogous to the relationship between content and metadata in digital data. Whereas an image is content, metadata would include the image's size, resolution, and date of creation; for an audio file, it might include the file format, the author, title, etc. So metadata is information about information, and reveals the hidden elements that can be used to identify similitudes between objects – in this case, where two audio files have something in common. When approached algorithmically, it is thereby possible for, say, iTunes to recommend music to you based on the resemblance of one audio track's metadata to another, without necessarily needing to know the content of those tracks. The more resolution there is in the metadata, the more accurate the similitudes. Given an ability to access these hidden properties directly, it would be possible to generate a series of similitudes that would work – i.e. be sympathetic to each other – yet that would reside outside ordinary empirical perception, removing the need for Foucault's external signatures.

With the digitization of many elements of daily life – communications, reading, music, entertainment, and social interactions – almost everything has metadata, including us. Of the classified documents leaked by Edward Snowden, the first to be published by *The Guardian* revealed that Verizon was required to hand over, in bulk, the telephone records of its customers to the National Security Agency. These records did not include the content of telephone calls, but rather the metadata associated with the calls: phone numbers, GPS coordinates, duration and time of calls, SIM card ID. Senator Dianne Feinstein, chair of the Senate intelligence committee, wrote in USA Today: "*The call-records program is not surveillance. It does not collect the content of any communication, nor do the records include names or locations. The NSA only collects the type of information found on a telephone bill*". [3]

[3] http://www.usatoday.com/story/opinion/2013/10/20/nsa-call-records-program-sen-dianne-feinstein-editorials-debates/3112715/, accessed June 15th, 2015

Here, Feinstein differentiates between metadata and surveillance – a controversial distinction that many would contest. To follow the NSA's logic, 'surveillance' would be limited to the collection and analysis of the *content* of conversations that, presumably, people deliberately participated in. In contrast, metadata constitutes supplementary information that is inadvertently generated—for instance, the time and duration of a call. The distinction between surveillance of content and metadata points to the expanded scope of observational systems. The transition from analog communication to digital information systems permits the easy filtering, evaluation and comparison of indexed data, and following Foucault, allows hidden relationships to emerge. It also demonstrates the extent to which social media networks such as Facebook rely entirely upon metadata. The actual content of peoples' individual status posts is largely irrelevant, other than in terms of specific keywords (i.e. the post represented as a form of metadata). Demographics, device-types, location, mobility, and 'likes' are much more valuable in terms of building up a profile of people as potential customers to sell things to. As such, Facebook should be seen as the pre-eminent self-surveillance network of our time, successfully combining a commercial business model with voluntary self-surveillance. So in one context – the Snowden leaks – we fight to protect the privacy of our telephone conversations; in another context – social media – we voluntarily donate intimate personal information to a corporate entity, even now in the knowledge that this data is being siphoned off by the NSA.

Sites like Twitter and YouTube do not acquire the quantity of personal-related metadata that Facebook does, simply because they do not incorporate as many data-points into their system. Where Facebook succeeds is in finding virtual analogies for so many aspects of

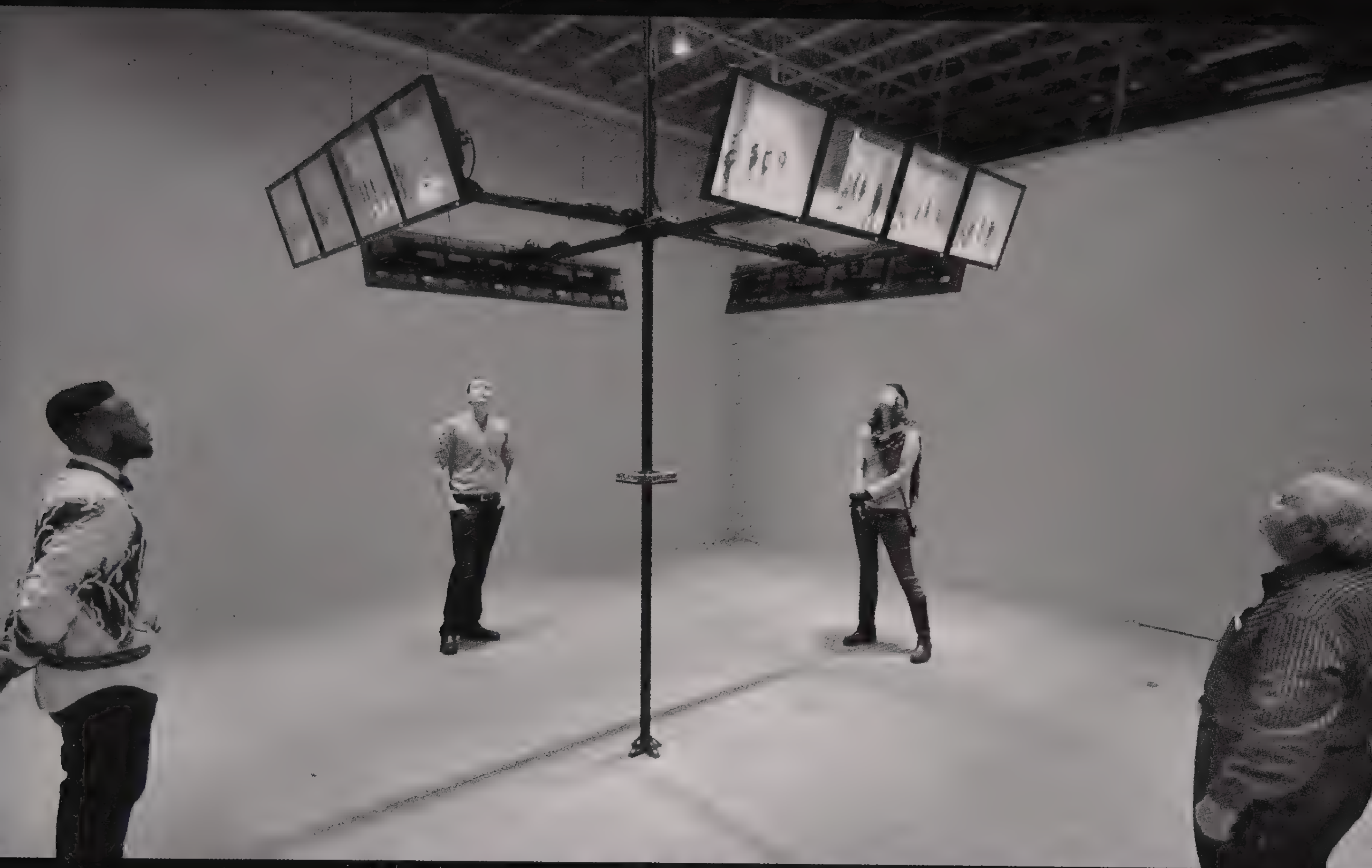


Figure 1. James Coupe, *Swarm* (2013). Photo credit: Aaron Wilcox.

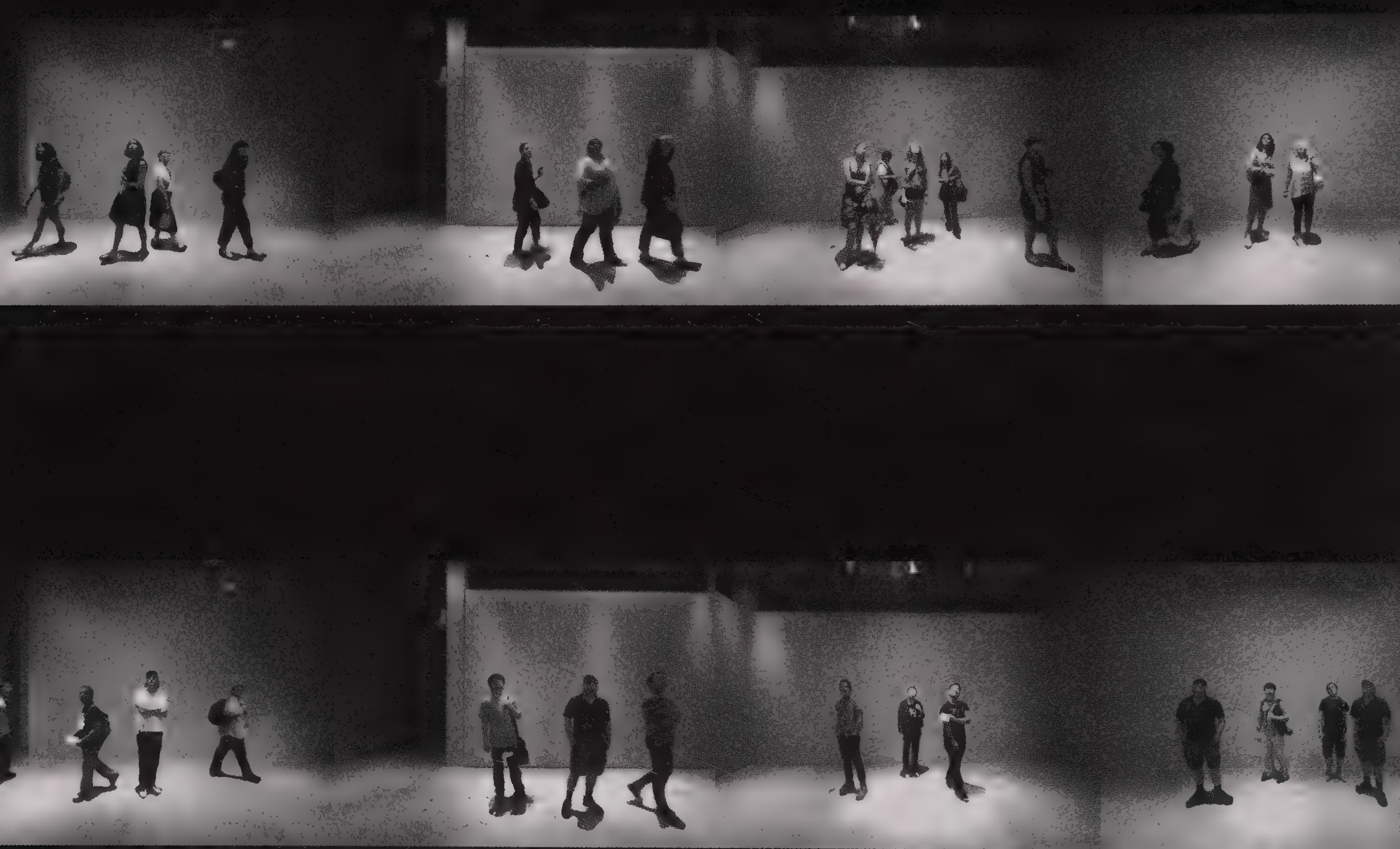


Figure 2. James Coupe, *Swarm* (2013).

our real-world lives – work, friends, emotions, events, births, deaths, etc. This provides Facebook with an enormous ability to accurately narrativize our lives based purely on metadata. Interestingly, this becomes mutually beneficial – through such 'big data' systems, we can find patterns that may not be apparent in real life. So here the machine takes charge: the scale of the data is beyond our empirical capabilities and can show us things about ourselves that we would not be able to perceive without it.

The ability of metadata to generate narrative can be seen in my recent video art installation – *Swarm* (2013). *Swarm* takes the logic of social media – demographically organized communities based around common interests, habits and economic status – and transposes it onto gallery audiences. Using four rows of monitors, the work generates competing panoramic representations of the gallery space that appear to be exclusively occupied by specific groupings of people – men in their 20s, women in their 50s, people of Asian descent, people dressed in black, men with beards. Each group is shown as what appears to be a live panoramic video image, with people inserted into a 'crowd' alongside others who have previously visited the gallery. Some crowds are much larger than others – a large group of middle-aged white women on one panorama, standing around, waiting for something to happen, may juxtapose with a solitary Latino male on another. Different demographic groupings territorialize the gallery's spaces, their numbers dynamically expanding and contracting.

Swarm, like many of my other works, uses computer vision algorithms to profile people via live video cameras. The cameras identify faces and then analyze the landmark features of those faces – relationships between eyes, nose, mouth, jawline, etc. These features are then compared to those in a large database of pre-tagged faces, and the age, gender, race, facial expression, etc. of the person in the gallery are estimated. The system works with metadata – it is not looking for specific individuals, rather it is looking for characteristics and then comparing them to existing patterns based on the metadata of others. It calculates the locations of people inside the gallery space and uses those to figure out how to build crowds of people, again based on positional metadata. As is the case with social media sites such as Facebook, participation is automatic; to be present is to become content. On each row of monitors, there are dynamically generated groupings of people, and these are based on what the metadata can show us – groupings based on how the computer organizes humans, what the majority is, what the outliers are. The various narratives that are inferred from those groupings are essentially the same ones that drive the NSA's logic.

Where does this correlation take us? *Swarm* relies on our understanding and experience of metadata to make sense to its audiences. Social media, by finding patterns within our personal data, trains us to understand the way metadata works as narrative. A Facebook front page, for example, is a succession of text, announcements, images and videos from other people, whose only connection to each other is our own metadata. Yet somehow we are not overwhelmed – the simultaneity makes sense to us as we find a way to join them together into something coherent. So the groupings in *Swarm* are familiar and recognizable, showing us the extent to which we have become used to algorithmically constructed communities as a way of experiencing the world, and to finding ourselves inserted into groupings of people based upon our metadata. *Swarm* removes these groupings from their familiar commercial context and as a result is more oppressive, exclusionary and menacing. The algorithm is visible and present, assuming control of our metadata and using it to construct narratives that we can exert very little control over.

Swarm was inspired by J.G. Ballard's *High-Rise*, a novel in which people live in close proximity in a one-thousand unit, modern apartment building. Eventually, the pressures of isolated yet claustrophobic living causes the residents of the high-rise to form clans, organized around class demographics. The situation rapidly becomes monstrous, as residents begin killing each other in order to regain control of their environments. For Ballard, the residents are cool, unemotional, desensitized, with minimal need for privacy and capable of thriving within the closed environment of this "malevolent zoo":

> [The residents had] no qualms about the invasion of their privacy by government agencies and data-processing organizations, and if anything welcomed these invisible intrusions, using them for their own purposes. These people were the first to master a new kind of late-twentieth century life. They thrived on the

Figure 3. James Coupe, *On the Observing of the Observer of the Observers* (2013). Photo credit: Erika Herrera

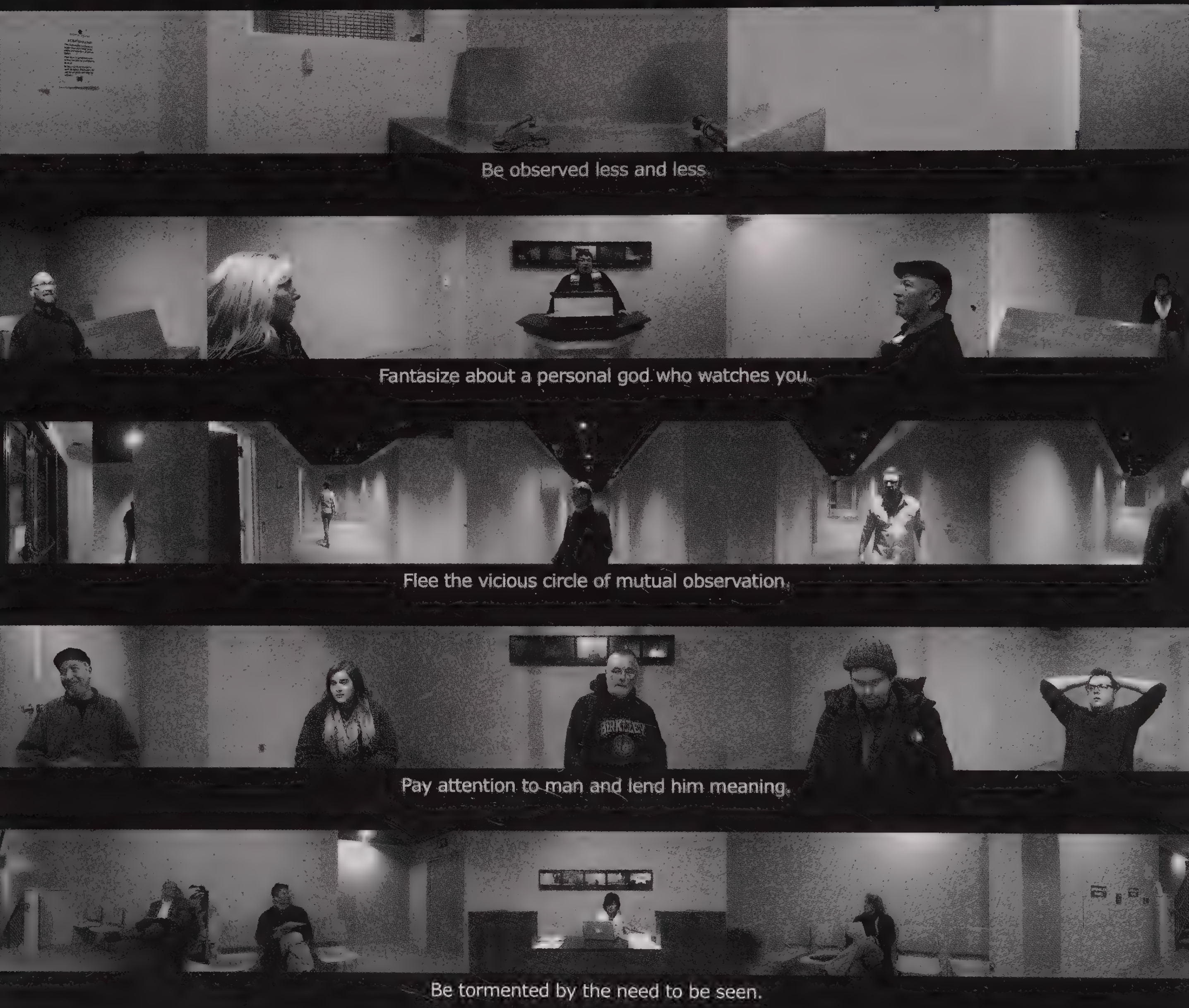


Figure 4. James Coupe, *On the Observing of the Observer of the Observers* (2013)

> rapid turnover of acquaintances, the lack of involvement with others, and the total self-sufficiency of lives which, needing nothing, were never disappointed.[4]

[4] J.G. Ballard, *High-Rise*, (Caroll & Graf, 1989), 36

Ballard's isolation/proximity dialectic is useful in thinking about metadata. Social media isolates individuals by creating a customized, unique experience with content generated specifically for you, based on your demographic, purchasing habits and interests; it also relies upon proximity by calculating your similarity to the profile of other individuals. Inside this framework, we exchange privacy for an identity within a network of algorithmically determined similitudes. No longer is it about protecting our own subjective thoughts, rather it is about managing our external (metadata) identity and ensuring that the system sees us correctly. We can become virtuosic operators within this claustrophobic environment – as Ballard recognizes, we use the situation "for our own purposes." An advanced understanding of how a network sees us requires an awareness of the metadata that we generate within it, and for us to perceive ourselves as isolated and connected at the same time.

On the Observing of the Observer of the Observers (2013) is an installation that explores this interdependence of the individual and the masses. All visitors become participants, and everyone observes and is observed. The work incorporates a labyrinthine sequence of rooms, each containing five cameras and five monitors. The cameras are positioned in a ring in the center of each room, capturing a 360-degree panorama that is then displayed on the screens. Each camera runs computer vision algorithms that determine what they record and what they ignore, selectively sending video to the monitors to display a panoramic view of the gallery space that is asynchronous. Each camera will only record video when a single individual is in the shot. When spliced back together to form a panorama, those individuals find themselves paired up with one other person, or four others, or none – each room has a unique set of rules that it follows to recomposit the footage that it captures. Some blend staged footage – the Asch conformity test, a religious sermon on God as voyeur – with gallery visitors.

Each room's latest footage is autonomously distributed to a screening room, where it is spliced into a ten-minute narrative film, using a series of instructions adapted from Friedrich Dürrenmatt's 1986 novella, *The Assignment* as subtitles and voice-over. The instructions (for instance, "Try not to be observed", "Pay attention to man and lend him meaning") sound like self-help-style directives, perhaps providing a source of comfort as people find themselves encountering a taxonomy of individuals in the installation, some live, some archived, some previously recorded versions of themselves. Every person's experience of the work is unique, as it constantly reconstructs itself based around their identity and passage through the installation.

The Assignment revolves around the disappearance of Tina Von Lambert, who leaves behind a diary with a final entry that simply states, "*I am being observed.*" It is unclear if this refers to the meticulous studies her psychiatrist husband makes of her, or if it is a positive acknowledgement that, at last, someone is paying attention to her. Later in the story, a logician develops a theory of observation that connects war, science, terrorism, marriage and God. According to the logician, people have an inherent need to be seen, without which they would feel insignificant and depressed:

> … [he] would have to conclude that other people suffered as much from not being observed as he did, and that they, too, felt meaningless unless they were being observed, and that this was the reason why they all observed and took snapshots and movies of each other…[5]

[5] Friedrich Dürrenmatt, *The Assignment* (University of Chicago Press, 2008), 19.

So here observation is a self-perpetuating loop between content and metadata. Awareness of how we are seen determines how we present ourselves. A desire to be validated as meaningful by metadata-seeking systems encourages us to contribute more personal content. So, potentially inverse to our expectations, we are creating content in order to generate metadata. Social media provides us with the tools to verify that when we ask to be observed, someone is watching. For what is a Facebook post without at least someone 'liking' it? Or a tweet with no followers? Or a YouTube video that no one watches? Metadata is much crueler than this, however: while it may give us the impression that we can strategically oscillate between observer and observed, between exhibitionist and voyeur, the reality is that every click, scroll and pause generates data for the networks that provide them. Ken Rudin, head of Facebook analytics, has discussed cursor tracking as a means of generating additional

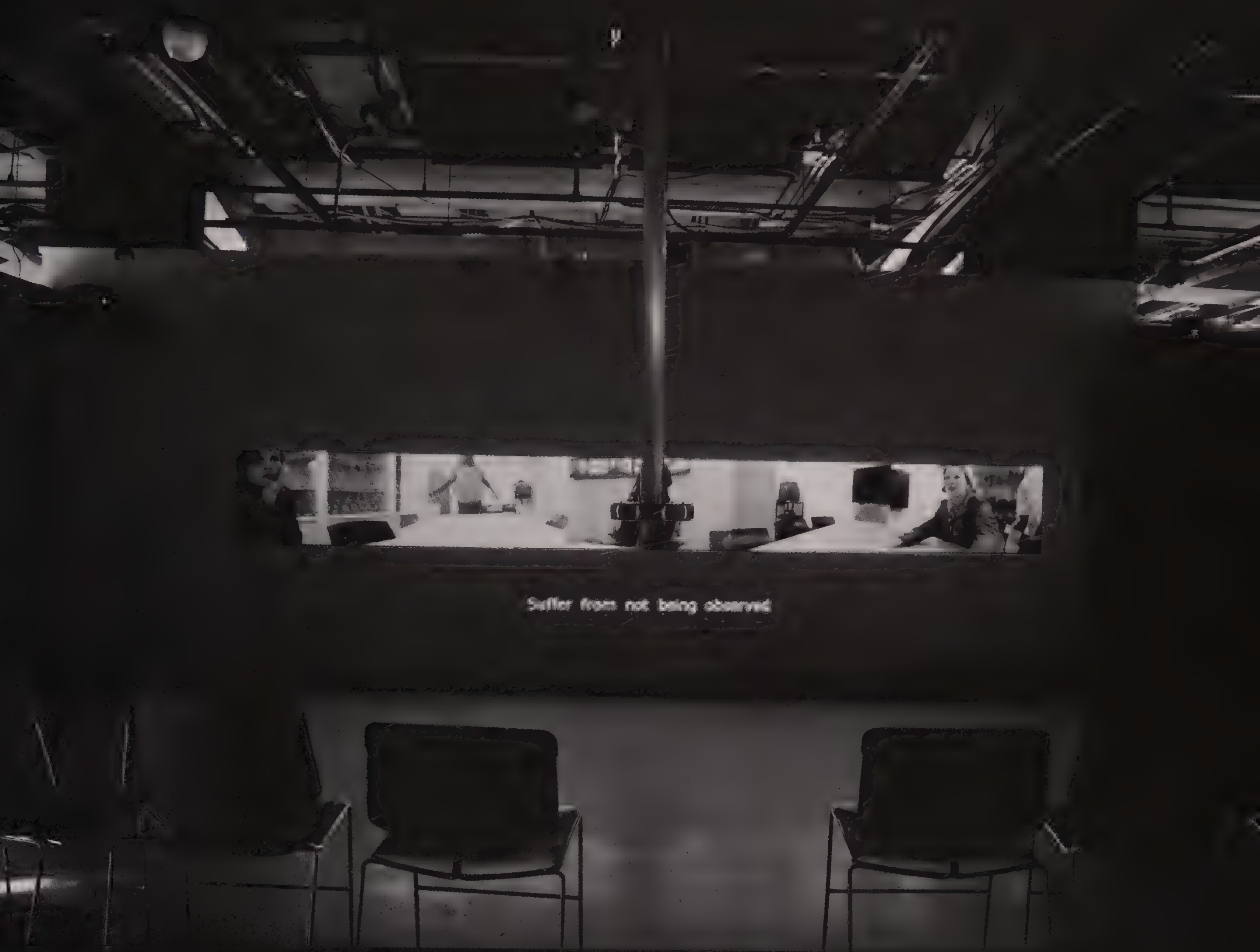


Figure 5. James Coupe, *On the Observing of the Observer of the Observers* (2013)

Figure 6. James Coupe, *Today, too, I experienced something I hope to understand in a few days* (2010)

metadata[6], converting users into active observers, tracking our gaze and connecting us with products we didn't even realize we wanted. Even when we just want to watch, we also perform for the network.

[6] http://blogs.wsj.com/cio/2013/10/30/facebook-considers-vast-increase-in-data-collection/, accessed June 15, 2015

Today, too, I experienced something I hope to understand in a few days is a Facebook application that I created, built from three sources, each a form of self-surveillance and reliant upon metadata to connect them together. First is a series of video portraits of people who volunteered to be filmed at specially arranged events organized in Seattle, Barrow and Manchester, using poses and actions loosely based on Danish experimental filmmaker Jorgen Leth's 1967 film *The Perfect Human*. The work's title comes from a line in the film. The videos are uploaded to a database where a program automatically edits them in the style of Leth's film, using metadata extracted from the original cinematography – duration, type of shot, gender of subject. The second source is text from the status posts of people who have voluntarily signed up to the project's Facebook application. In so doing, all the status posts they have ever made are put into a database and mined for narrative associations, before being joined together into a story. These narratives, made up of multiple status updates, are then overlaid as subtitles on video portraits of people whose demographic matches those of the original post. Lastly, YouTube videos with tags that match keywords in the status posts are automatically downloaded, and displayed next to the video portraits as a split-screen video. The resulting video is then uploaded to YouTube, and also put onto the Facebook page of all subscribed users.

The project generates videos based entirely on metadata, and has been described as "*tapping into the sadistic voyeurism behind the benign face of cool*".[7] The passive activity of simply being part of social networks such as Facebook generates commercial associations that are algorithmically determined – health, real estate, fashion, and car products based on a person's age and gender. By taking an individual's status posts and combining them with those of other people that are thematically or grammatically linked, *Today, too, I experienced something I hope to understand in a few days* flattens subjectivities. People become data for the system, automatic participants appropriated by an algorithm. When combined with YouTube videos based purely on common keywords, the semantics become even

[7] Maria Walsh, *James Coupe: Today, too, I experienced something I hope to understand in a few days*, Art Monthly, October 2010, 37

further skewed – not totally irrational, after all this is a prime example of Foucault's similitudes, but into a space where the algorithm reveals its rules. This is the sadistic voyeurism – where the voyeur is the network, persistently and with no regard for the individuals finding relationships between products and human beings, for the price of those humans wanting to be connected to other people and feel a sense of community. Returning again to Dürrenmatt's prescient pairing of being seen with meaningfulness, where people constantly "*observed and took snapshots and movies of each other*", social media provides us with a kind of transactional observation, where in order to see oneself as part of a community, one must submit one's metadata to the commercial gaze that underpins it.

Geographer Michael Curry's 2003 paper, *The Profiler's Question and the Treacherous Traveler: Narratives of Belonging in Commercial Aviation*, articulates the close relationship between data, profiling and narrative. Curry traces the attempts made by the airline industry to figure out if an air traveler was "*a known and rooted member of the community*".[8] In the early days of commercial air travel, flying was an exclusive activity because it was expensive, meaning that the reasons for people to fly were relatively limited. These limitations meant there were a small number of profiles for a 'normal' traveler, which made people outside that norm stand out more easily. These profiles could be easily transposed onto a narrative – a well paid businessman on a business trip to meet with other executives would be the norm; a criminal with a gun in his hand baggage who will try to divert the plane to his homeland and make a getaway, the exception. Security measures were designed based on these narratives – searching hand baggage, filtering out passengers with one-way tickets bought with cash, etc. As air travel became cheaper and more popular, the profiles, and thereby the variety of narratives, also expanded exponentially. At that point the profiles needed greater resolution – they needed more metadata – in order to infer the content of their journeys. Consequently airlines began to require more personal information such as photo IDs, passports, ZIP codes, and credit cards, these can be considered as ways of obtaining that metadata and to accessing histories which could flesh out the narratives of individual passengers. The 'content' of a person's journey – i.e. asking that person face-to-face for their reasons for travel – were less reli-

[8] Michael R. Curry, *The Profiler's Question and the Treacherous Traveler: Narratives of Belonging in Commercial Aviation, Surveillance and Society*, Vol. 1, Issue 4, 476.

able than the metadata associated with the journey (age, gender, travel companions, method of ticket purchase, seat selection, travel history, etc.).

The strategies that Curry describes are equally applicable to airlines, NSA, advertising and marketing. As he says,

> If one knows a location – a street address, wired-telephone number, latitude and longitude, or even airline flight and seat number – one can use that datum as a means of associating activities and participants one with another, and creating an image of the whole. The desire may be to find potential deodorant buyers or potential hijackers, but the method can be the same.[9]

[9] Ibid., 493.

Curry's observations show once again that visible or aural content is not as valuable for surveillance purposes as metadata. It also hints at the capability for narrative to be algorithmically generated – i.e. to respond directly to the currently available metadata, where a story is based on the demographics, locations and preferences of a community of people. In this sense, it is dangerous to impose pre-determined narratives because those may not take account of the aspirations, motivations and anxieties of specific profiled groupings. Narratives need to be dynamic and emergent, potentially based on possibilities that we cannot see ourselves. As is the case with *Today, too, I experienced something I hope to understand in a few days*, narrative is a dynamic thing that can shift in direct response to real world events, and as a result keeps pace with current social and technological paradigms.

Our everyday digital experiences are largely shaped by metadata. 'Big data' refers to datasets built from metadata that are too large to be processed by human beings. Despite the fact that big data is premised on surveillance paradigms, it has the potential to benefit us in new ways. The journal *Nature*, for instance, published a report that Google could predict the spread of winter flu more accurately and quickly than the Center for Disease Control, simply based on where and when people submitted flu-related queries to their search engine.[10] Although the robustness of such an approach is still open to question, big data points towards an increasing dependence on metadata to structure how we solve real world problems.

[10] http://www.nature.com/news/2008/081119/full/456287a.html, accessed June 15, 2015

As an artist who works with metadata substantially, is my work complicit with the NSA? As Curry demonstrated, metadata is not the preserve of security agencies, it has been a tool of marketing agencies for many decades. And now that we are so reliant on digital tools, we are also generators of, manipulators of, and subjects of metadata. Simply, it is part of our lives. For artists, it is important that we make work that explores these issues.

The Australian Philosopher Peter Singer, in writing about the ethics of surveillance, contends that the scale of the NSA's data gathering and the structure of the Internet has made it possible for us to gain access to government activities in ways that were not previously possible. In other words, organizations like WikiLeaks would not be able to publish classified documents unless a sophisticated system was in place to create and share them in the first place. He suggests that this

> could be the perfection of democracy, the device that allows us to know what our governments are really doing, that keeps tabs on corporate abuses, and that protects our individual freedoms just as it subjects our personal lives to public scrutiny.[11]

[11] Peter Singer, *Visible Man*, Harpers Magazine, August 2011, 32.

So arguably there are more opportunities for artists to infiltrate, occupy and critique real-world systems than ever before. We all observe and are observed, including the government. The Snowden leaks have forced the NSA to justify their surveillance methodologies and have encouraged a more open and informed discussion about how we want to be governed. Clearly artists need to participate in this dialog, but finding ways to include art in this loop is far from straightforward – Julian Assange is in the Ecuadorian Embassy, Edward Snowden is in hiding in Russia, Chelsea Manning is in military prison. For an artist, or a museum to attempt to build a project that uses similar strategies to the systems unraveled by these people could constitute a serious risk.

In *Sanctum*, a public art work from 2013, some of the obstacles artists face in attempting to work in the domain of surveillance and data gathering were revealed. Installed on the façade of the Henry Art Gallery at the University of Washington (UW) in Seattle, *Sanctum* uses six video cameras to track and profile people as they walk towards the gallery.

Figure 7. James Coupe and Juan Pampin, *Sanctum* (2013)

Figure 8. Signs for *Sanctum* – initial version on the left; amended version on the right.

Once they have been profiled, voices that match their demographic are beamed at them via ultrasonic speakers. The voices read out narratives built from Facebook status posts, again matching their demographic. As they get closer to the gallery's façade the voices become clearer, eventually resolving into a single voice. Once within 12 feet of the façade, a person's live image is put onto video monitors that wrap around the gallery, paired up with other people that match their demographic, and with the Facebook narrative as subtitles.

The development of *Sanctum* was complicated by the legal issues involved in placing surveillance cameras in a public space, the works use of profiling, its use of fictional narratives juxtaposed with live images of people, and the amount of risk that the gallery and the university was willing to assume. Consent was at the heart of the problem - legally we did not require consent to film people in public spaces, or to use the profiling algorithms. However we did require consent to show people in a false light - i.e. overlay narratives onto their image based on their metadata (ironically the very same process by which social media and the Internet automatically conflate our metadata with consumer narratives). The solution for this, through consultation with the UW Law School, the Attorney General's office and the UW Office of Risk Management, was to install signs at all approaches to the gallery, informing people that by entering the area they would be consenting to be recorded and to have their image used in a fictional narrative. Further, a restriction was placed on where the project was permitted to profile people – only when people were within 12 feet of the façade were we allowed to detect peoples' age and gender.

Interestingly, the initial assumption was that people would object to being profiled and recorded. Gallery staff were instructed not to use the word 'profiling' when discussing the work with members of the public. The first version of the signage for the project produced by the gallery did not encourage people to participate in the work, and was only changed on insistence from the artists. Contrary to these initial fears, the work has been extremely successful and at the time of writing, no complaints have been filed since the project launched. Instead, interesting behaviors have emerged: people using the work to leave messages for others in the system, people uploading images onto Facebook of themselves as seen by the system, people staging performances in front of the façade. These are people who understand the system's logic and are skilled manipulators of metadata.

A work like *Sanctum* perhaps reinforces Peter Singer's theory concerning the ethics of surveillance. The standards by which we distinguish between public and private have changed substantially with the advent of social media and the Internet. In *Sanctum*, any loss of privacy is a *choice* that people are given the conscious ability to make. Once given that choice, people by and large want to explore it – in the same way that social media appears to offer us something to explore. What does this environment look like? How does it feel to be in a physical public space that combines layers of virtual 'public' space such as Facebook? *Sanctum* creates such a space, allowing people to explore narrative, metadata, and profiling, and to potentially become more strategic users of those things. In November 2014, the Henry Art Gallery organized a symposium about *Sanctum* and the issues of surveillance and privacy that it confronts. Speakers included Cory Doctorow, Marc Rotenberg and Lauren Cornell, with a goal to take lessons from *Sanctum* that can allow other galleries and artists to make work that explores these ethical, legal and institutional grey areas. It is vital that artists can make work that uses the same tools deployed by governments – not painting pictures of these scenarios but operating in the same reality, with the same methods recast. Only then can we attain a critical position capable of meaningful understanding with real-world implications and impact. As Hans Haacke once said, "*the system is not imagined, it is real*". [12]

[12] Jack Burnham, *Great Western Saltworks* (George Braziller, 1974), 22.

More broadly, what does it mean for art and artists to operate within environments where metadata increasingly supersedes content? What happens to the art object, what happens to artistic practice? What skills does an artist need to have today? It's extremely important that artists continue to interpret, reflect, critique and comment, that they have the skills and the platform to irritate the systems we live alongside, and vitally, use the right tools for the job. Traditional art materials are increasingly inadequate for this, hence the need for artists to be hackers, programmers and highly conversant with systems as well as objects. The works that such artists make use technology but increasingly it is becoming hard to sustain a critical practice that engages with the world as we live in it without using or referencing technology in some way. Geert Lovink wrote recently that the Snowden revelations marked the symbolic closure of the "new media" era[13]. So now rather than digital art, we must talk about art in the age of digital media, and work out how to prepare ourselves accordingly.

[13] Geert Lovink, *Hermes on the Hudson: Notes on Media Theory after Snowden*, e-flux journal #54, April 2014.

Perceptual Ecologies: Mine

Dan Overholt and
Esben Bala Skouboe

The word ecology can be used to describe the environment that surrounds us biologically, socially and technologically. The quest to explore and better understand new aesthetic and perceptual possibilities of mediated realities could lead us towards new ecologies. This is what drives the active development of the artistic projects discussed in this chapter. These endeavors allow for exploration and real-world observation of the conceptual, theoretical and perceptual aspects of adaptive ecology-inspired approaches to worldmaking. We approach the concept of world-making using the term atmosphere as an abstract machine with which to establish a common ground, uniting the disciplines of music and architecture into a world of 'living' perceptual compositions: Perceptual Ecologies.

We have several primary sources of inspiration that carry us into the domains of complexity theory and ecosystems. First, Umberto Eco´s iconic article "The Open Work"[1], which discusses the link between contemporary scientific views and the structuring of artistic forms. It alludes to Einstein´s concept of relativity, in which time and space are co-dependent, to contrast the hierarchical scientific world and artistic practice. As Eco notes, a change in worldview can be observed in comparison to the music of each age.[2] Much has changed since 1959, and we now face new challenges in scientific thinking, e.g., that of Complexity Theory. Jack Burnham describes the function of system-based art by stating that "the specific function of modern didactic art has been to show that art does not reside in material entities, but in relations between people and the components and their environment".[3] If we then approach the environment as part of an ecosystem, perhaps we can craft aesthetic systems that exhibit novel conceptual and perceptual richness, containing new types of visionary atmospheres.

[1] Eco, U. 'The Poetics of the Open Work'. In Cox, C., Warner, D. (eds.) *Audio Culture: Readings in Modern Music* (New York and London: Continuum, 2004 [1959]).

[2] Davis, T. 'Complexity as Process: Complexity-inspired approaches to composition,' *Organised Sound*, Volume 15, Issue 02, (2010): 137-146.

[3] Burnham, J. 'Systems Esthetics'. *Artforum*, 7, (1968): 30–5.

When entering the artistic domain of Perceptual Ecologies, we are interested in complex sonic and visual spatial forms that alter a unique perceptual experience associated with living relationships between people and mediated environs (an ecology). Moreover, through the act of making, generative musical compositions and responsive instruments form living relations with environmental dynamics. We search to address potentially surprising and sensitive worlds in a highly complex ecological context. This is a process of techné.

Atmosphere as a common ground

Approaching the creative process of crafting a perceptual experience in an ecological domain of living relations demands theoretical skills in navigating complex systems, as well as traditional skills from material and technological practices. Combining these tools allows artists to build aesthetic systems that address dynamic expressions of change, presenting alternative 'living' visual and aural compositions in direct relations with algorithmic and local processes. These new perspectives challenge artists to develop a common ground uniting static disciplines such as sculpture, painting, architecture, and music composition, with dynamic disciplines such as performance, lighting design and interaction design. In order to approach these emergent trans-disciplinary expressions/compositions, the term "atmosphere" emerged as a conceptual tool to establish a common ground between musicians, architects and interaction designers.

"The atmosphere is like a cloud hanging in the air, which has the potential for changing your mood".[4]

[4] Böhme, G. Urban *Atmospheres: Concept and Criticism of Making Atmospheres* (Copenhagen, DK 2011).

According to the German philosopher Gernot Böhme, atmospheres are highly subjective. He describes a metaphorical "cloud" hanging in the air, affecting passersby. A wide range of external forces continually transforms the cloud, changing the experience in a highly dynamic nature. It radiates from everything: trees, weather, colors, architecture, sculptures, music, paintings, smiles, tone of voice, etc., all of which contribute to the development of a state of mood specific to a certain time and place. By performing (e.g., singing, playing music, or simply shouting, smiling, talking), anyone and everything can affect the atmosphere, with the potential of changing others' moods. As such, we can all affect the appearance and behavior of the metaphorical cloud, and it becomes evident that we all continually contribute to the creation of an atmosphere which in turn affects the experience.

This constructive approach to social atmosphere is also supported by the observations of sociologist Erving Goffman, who described how people can't stop sending social signals, affecting others in the situation.[5] While Goffman did not use the term atmosphere in his writing, he did address collected agency as a social structure that individuals engage in while performing or being social. He found that people employ a series

[5] Goffman, E. *The presentation of self in everyday life* (New York: Doubleday, Garden City, 1959).

Figure 1: *Perceptual Ecologies*, an interactive installation exploring the concepts of ecologically inspired generative and responsive systems. Photo: Morten Hilmer.

of interaction rituals in order to navigate through the social situations of everyday life. Mechanisms such as mirroring, face-saving rituals, civil inattention, ignorance, etc. are examples of social cues that exhibit the exchange of information between individuals – intentionally or unintentionally affecting their social environments. The atmosphere is a subjective and social phenomena people share in creating while observing, producing, and maintaining presence. We can illustrate the mechanisms as a feedback loop between the metaphorical cloud and the actors, being living, communicating organisms or non-living actors (Figure 5).

Norbert Wiener[6] and Gordon Pask[7] show that the collective information exchange between individuals in large systems is similar to the feedback loops described by cyberneticians such as Heinz von Foerster.[8] Such systems can also be described as complex systems. According to these theories, people become social agents both affected by and affecting their environments, typically following certain rules to engage in a situation.[9]

In the Perceptual Ecologies installation (Figure 1), people continuously exchanged information with each other while observing and interacting with the instruments developed for the environment. They affected each other's social practices, and produced effects that can sometimes lead to surprising social events. A similar yet much more explicit example occurs when "musicians alter the atmosphere, potentially causing people to move synchronously; nodding their heads or even dancing".[10] Sound and music perception as a means of directing certain social agencies have been demonstrated to create various social traits, such as: aggressive behavior[11], physical attractiveness[12], helpfulness[13], pain management[14], and time perception.[15] These studies provide evidence that human agency can be strongly affected by sound compositions. Within the experiment of Perceptual Ecologies, responsive soundscapes were composed that functioned as infrastructures for communication, motivating social exchanges and collaborations amongst strangers. One of the projects goals was to shape people's social behaviors through sculptural interactive instruments designed to influence their actions over time, and thereby the atmosphere in the environment: an abandoned underground limestone mine.

[6] Wiener, N. *Cybernetics or Control and Communication in the Animal and the Machine* (Cambridge, Mass.: MIT press, 1965).

[7] Pask, G. 1962; *An approach to cybernetics* (New York: Harper, 1962).

[8] von Foerster, H. 'On Constructing a Reality,' *International Conference on Environmental Design Research* Virginia Polytechnic Institute, Blacksburg, April 15 (1973).

[9] Miller, J.H. & Page, S.E. *Complex adaptive systems: An introduction to computational models of social life* (New Jersey: Princeton University Press, 2007).

[10] Leman, M. *Embodied Music Cognition and Mediation Technology* (Cambridge, Mass.: MIT Press, 2008).

[11] Konecni, V.J. 'Social interaction and musical preference,' in D. Deutsch (Ed.) *The psychology of music* New York: Academic Press, 1982): 497-516.

[12] Zillmann, D. & Bhatia, A. 'Effects of associating with musical genres on heterosexual attraction,' *Communication Research*, 16, (1989): 263–288.

[13] Fried, R., & Berkowitz, L. 'Music hath charms and can … influence helpfulness,' *Journal of Applied Social Psychology*, 9, (1979): 199-208.

[14] Standley, J. 'Music as a therapeutic intervention in medical and dental treatment: Research and clinical applications,' in T. Wigram, B. Saperstone, & R. West (Eds.), *The art and science of music*

Through the process of developing the installation, it was found that central aspects of a social atmosphere can be mediated by adaptive cybernetics-inspired compositions of sound, visuals, and movement. These interactive configurations can encourage occupants to join in a social behavioral domain, engaging in the mediated atmospheric feedback loop. Such systems do not need overt means of persuasion, but can provide subconscious cues and rely upon innately human traits such as imitation and 'conversation' with the composed elements of the atmosphere. Artists and craftsmen of all ages have known that they can use the tools and techniques at hand to actively shape a mediated atmosphere. The vision of Perceptual Ecologies similarly focused on the creation of artifacts to address an ecological world of 'living' social and environmental relations in the responsive space. The approach to designing an experience in time and space was taken from the domain of complex system theory, specifically focusing on the concept of ecological processes.

Ecological processes

The term ecology (ökologie) was coined by Ernst Haeckel in 1866 as the "science of the relations between the organism and the environmental outer world"[16], and later by the biologists Günter Vogel and Hertmut Angermann who explained it similarly as "the study of the interrelations between organisms and their environment".[17] Although the term originates from a branch of biology, the fundamental principles have inspired various scientific disciplines to think about networks and living relations: philosophical ecology[18] [19], ecology of the mind[20], sociology[21], ecological aesthetics[22] [23], ecological theory of cognition[24], sound art[25] [26], and soundscape analysis.[27] It is not necessary to propose yet another subgenre of the concept, nor to prove that such exists, but rather to acknowledge that broad trans-disciplinary theoretical frameworks use ecology as a means to describe how subject and context relate in contextual complex systems.

To approach an ecologically inspired worldmaking paradigm, one might choose to follow in the footsteps of Craig Loehles[28], who disassembles the complexity of ecologies with six dimensions: spatial,

therapy (Langhorne: Harwood Academic Publisher and Gordon and Breach Science Publishers, 1995).

[15] Kellaris, J. J., & Kent, R. J. 'The influence of music on consumers' temporal perceptions: Does time fly when you're having fun?,' *Journal of Consumer Psychology*, 1, (1992): 365-376.

[16] Haeckel, E. *Generelle Morphologie des Organismus, Bd. 2: Allgemeine Entwicklungsgeschichte*. Reprint. (Berlin: de Gruyter, 1866): 286.

[17] Vogel, G., and Angermann, H. *Dtv-Atlas zur Biologie*. 12th ed. (München, 1977).

[18] Sachsse, H. *Ökologische Philosophie* (Wiss. Buchges: Darmstadt, 1984).

[19] Attfield, R. *Environmental Philosophy* (Aldershot: Avebury, 1994).

[20] Bateson, G. *Steps to an Ecology of Mind* (Ballantines: New York, 1972).

[21] Luhmann, N. *Ecological communication*, London: Westdeutscher Verlav, 1986).

[22] Böhme, G. *Natürliche Natur* (Frankfurt: Suhrkamp, 1992).

[23] Krampen, M. *Meaning in the Urban Environment* (London: Pion, 1979).

[24] Gibson, J.J. *The Ecological Approach to Visual Perception* (Boston: Houghton Mifflin, 1979).

[25] Davis (2010): 137-146.

[26] Biasutti, M. 'Psicologia e Educazione Musicale.' *Proceedings of: PME04: International Symposium on*

temporal, structural, process, behavioral, and geometric. Architecture has a history and language related to spatial, structural and geometrical studies (appearance) while the history and language of music addresses the remaining three dimensions: temporal, process, and behavioral (compositions). This dualism motivates collaboration between musicians and architects in the exploration of new perceptual expressions in a wide range of ecological and highly dynamic contexts.

Within the discipline of architecture, the term ecology has been used as a fundamental framework for understanding how the components of a living system function together. Ultimately, truly environmental architecture cannot be reached through the refinement of the static object alone, but must address complex interactions between building and environment, and these interactions are best understood through a study of ecology.[29] According to such ideas, architecture is mediated by various technologies and can exhibit responsive, adaptive and generative behaviors.[30] [31] [32] In the article "Swarm Architecture", Kas Oosterhuis[33] describes an architecture that is changing its expression in real-time. These contributions acknowledge an animated architecture that has innate behaviors, but none directly treat the spatial response patterns as a musical composition utilizing mechanisms such as rhythms, intensities and pitch to present novel aesthetical spatial response patterns. In this way, architecture may still be able to glean much from the domain of music.

Approaching the concepts of ecologies and complex systems in the domain of sound and music requires to the exploration of at least three different areas. First, one can look at the analytical discipline of understanding and describing natural soundscapes as acoustic ecologies.[34] Second, many have examined the use of computation to generate musical compositions and produce new types of complexity, for example using swarm simulations.[35] [36] Such studies are often composed with the help of an algorithm, and realized in a concert setting that explores musical and spatial emergence. Third, research can delve into hybrid musical and spatial compositions, where control systems and environments are combined to produce several simultaneous forms of perceptual stimuli. These cases are often seen in art exhibitions and showcased in, for example, Gorden Pask's peace "Colloquy of Mobiles"[37], and later extended

Psychology and Music Education, Padova, Italy, (2004) 29-30.

[27] Truax, Barry (ed.) 'Handbook For Acoustic Ecology,' *The Music of the Environment Series*, No. 5, (Vancouver: A.R.C. Publications, 1978).

[28] Loehle, C. 'Challenges of ecological complexity,' *NCASI*, vol. 1, no. 1, (2003): 3.

[29] Batel, D. 'Interweaving Architecture and Ecology– A Theoretical Perspective.' (2004) http://www.casa.ucl.ac.uk/cupumecid_site/download/Dinur.pdf [accessed June 22, 2015]

[30] Beesley, P., Hirosue, S., and Ruxton, J. *Toward Responsive Architectures* (Riverside Architectural Press: Toronto, 2006).

[31] Bullivant, L. (Ed.) *4dspace: Interactive Architecture* (Wiley-Academy: London, 2005).

[32] Kronenburg, R. *Flexible: architecture that responds to change* (London, Laurence King, 2007).

[33] Oosterhuis, K. 'Swarm Architecture II,' in *Proceedings of Game Set and Match II conference* (Rotterdam: Episode publishers, 2006): 14-26.

[34] Truax, B. (1978).

[35] Miranda, E.R. & Bills, J.A. *Evolutionary Computer Music* (London: Springer, 2007).

[36] Bentley, P.J. (Ed.) (1999) *Evolutionary Design by computers* (Academic Press: London, 1999).

[37] Haque, U. 'The Architectural Relevance of Gordon Pask,' in *4dsocial: interactive*

into experimental musical pieces such as robotic music.[38] In many of these cases, instruments are treated as agents that have sensors and actuators in order to pick up, process and respond to contextual cues as part of a musical composition.

In an installation, "the environment is not something we control, but interact with, and exerts reciprocal effects on us; technology is not a means to exercise control, but again something we interact with that affects the courses of our actions."[39] This lack of direct control over the environment and the sonic composition makes the system a conversation that artists have to balance. Well-known artists including John Cage,[40] Iannis Xenakis[41], and others led the movement away from the traditional fixed system of common music notation into more conversational systems. This was driven by a desire for musical freedom and alternative methods of composing, typically involving stochastic elements that will change randomly from one performance to the next. They also searched for ways to decompose the existing harmonic system, and questioned traditional musical systems, confronting the fundamental question, 'what is music'? Who is the performer, the musicians, the composer, or the audience? Critical voices would claim that computer controlled systems were too predictable and limited in their aesthetic capacities. However, external environmental inputs might embrace and utilize their context, and in some ways inject non-random indeterminacy back into the system. Such musical systems are open to interaction, and can be considered as just one part of a complex ecology of music making.[42] These studies are central backgrounds in the exploration of compositions in the Perceptual Ecologies project.

design Environments (London: John Wiley & Sons, 2007).

[38] Kapur, A. & . Singer, E. 'A Retrieval Approach for Human/Robot Musical Performance,' *Proceedings of the International Conference on Music Information Retrieval,* Victoria, Canada (2006).

[39] Green (2006): 5

[40] Cage, J. *Notations* (New York: Something Else Press Inc, 1969).

[41] Xenakis, I. *Formalized Music: thought and mathematics in composition* / Iannis Xenakis, (Stuyvesant, NY: Pendragon Press, 1990).

[42] Davis (2010) 137-146.

Composing systematic behaviors of agents

In natural environments that include phenomena such as flocks of birds or schools of fish, adaptive behaviors can be the difference between life and death. Individual behaviors are a product of stimulus and response pairs for a given environmental setting, where the response is modulated by the active rule-set of behaviors based on internal goals and objectives.[43] In the field of robotics, Arkin describes one approach to control

[43] Reynolds, C.W. 'Flocks, herds and schools: A distributed behavioral model,' *SIGGRAPH Comput.Graph.* vol. 21, no. 4, (1987): 25-34.

mechanisms as a reactive model, tightly coupling machine perception and action. This is typically utilized in the context of motor behaviors, to produce timely automated responses within dynamic and unstructured worlds.[44] Incorporating adaptive capacities within such systems can lead to emergent phenomena[45] that start from simple local interactions and unfold into complex, surprising, and enriched patterns of behaviors. Such complexity emerges through interactions with the conditions of a local environment in which the agents (human and non-human) are placed. Musicians, designers and programmers building such systems and manipulating their rule-sets allow us to enter a world of sensitive and 'living' relationships with technology.

[44] Arkin, R.C. *Behavior-based robotics* (MIT Press: London, 1998).

[45] Meade, G.,H. The Philosophy of the Present (Chicago: University of Chicago Press, 1932).

John Holland[46] describes a design process for complex adaptive systems as follows: "A part of the modeling effort for any complex adaptive system goes into selecting and representing stimuli and responses, because the behaviors and strategies of the component agents are determined thereby. Rules are simply a convenient way to describe agent strategies". Both the composition of individualistic behaviors and the physical appearance (shape and functionality) of the agents are subject to design; it is the sum of these things that leads to the overall composition of the ecology. Composing behaviors of the individual agents have clear consequences on the global outcome.

[46] Holland, J.H. *Hidden Order: How Adaptation Builds Complexity* (New York: Basic Books, 1995).

For the Perceptual Ecologies installation, a generative composition was created which has some elements of musical form pre-defined, but also depends upon input from a multi-node sensor system to acknowledge occupants of the space (living and non-living). It therefore deals with two different types of agents, and two different types of conversations: first, the interactive instruments, and second, the human occupants.

The instruments responses can be triggered by other instruments or by humans, and likewise humans form connections to both instruments and other humans. It is interesting to compose the relationship between the two types of agents, creating a musical 'language' of communication that can evolve between the two acting "species". A musical composition was developed and divided into five different stages, each holding a unique rule-set that addressed both local as well as global response patterns.

An initial hypothesis of the work was that occupants could experience a causal relationship between their actions and the evolution of them through the stages of a musical composition. Simply through their presence, visitors engaged in a 'social' conversation that led them to either: 1) further engage in the exploration of the compositional system, and possibly establish a common language between the instruments and themselves, or 2) purposefully step outside of the active sensing zone of the instruments, thereby observing other occupants as performers, or 3) decide to leave the environment. The causal relation between instruments and performers afforded new social situations for the occupant to cope with, and held the potential for new social and musical discoveries. The notion of the importance of the observers' roles has been eloquently explored and described in more detail by sociologists and cyberneticians including Erving Gofmann[47], Gerorge Simmel[48], Heinz Von Foester[49] and Gorden Pask[50].

[47] Goffman, E. *The presentation of self in everyday life* (New York: Doubleday, Garden City, 1959).

[48] Simmel, G. 'The Metropolis and Mental Life,' in *Metropolis, Center and Symbol of Our Times*, ed. Philip Kasinitz (New York: New York University Press, 1995): 30-44.

[49] von Foerster (1973).

[50] Pask (1962).

Perceptual Ecologies: Mine art installation

Based on the theoretical principles and concepts described herein, the interactive installation Perceptual Ecologies was developed to embody and test these ideas in the real world. The project was realized as a responsive art and music experience inside the aforementioned abandoned limestone mine in Northern Denmark. The installation took place in two caverns, in which two independent interactive ecologies of sonic agents reacted to the presence and actions of visitors (as well as other agents' sonic and visual outputs). The project was shown as part of Port 20:10, an international art festival that took place in Denmark during October-November 2010.

During the design of the installation, the musical and architectural aspects were addressed together with the physical design of the instruments, using the common understanding of creating an atmosphere through the theories and methods already elucidated. Systems were developed to afford real-time feedback between the context and the occupants: social and sonic agents. The physical shape of the instruments and the spatial setting are represented in Figure 2.

Context: Thingbæk Limestone Mine

In the early 1900s Thingbæk limestone mine was active. In 1936, it was converted into a sculpture museum. Today it still functions as such, and thousands of small bats have also found their habitat in the dark and humid cave halls. During daytime they hang resting in the cave's ceiling. In the evening (or in a case of disturbance) they fly out to the nearby forest to hunt for food. The context of the mine is already extraordinary: the high humidity (97%), cold temperature (7° C), the clicking sounds of the bats, and the dark silhouettes of the limestone statues all contribute to a novel and unfamiliar atmosphere. To enhance this unusual atmosphere, fourteen large trees (six oak and eight birch) were brought in for the installation, and re-planted inside the limestone mine. The trees created an even more abstract environment that suggested a connection between being underground, being in a forest and also being among new technological life-forms that had not yet been discovered (see Figure 3).

Spatial Organization

The spatial organization of the installation in the caverns is as shown in Figure 4 Photo of interior Thingbæk limestone mine Interior.

(A) Shows the entrance to the limestone mine, (B) opens the first chamber holding the 'sound agent' installation, (C) the 'air flow' cavern (C), and finally to the small chamber (D) with live surveillance video feeds from the other two chambers used in the exhibition. This (D) chamber also included extensive explanations of the interaction and compositional systems, allowing interested visitors to gain a deeper understanding of how their occupancy affected the installation. This serial spatial organization allowed visitors to explore and investigate the interaction system; first, they develop a set of internal hypotheses of how and why the agents would react and later they could return to the system with more knowledge about the dependencies and relations between compositional state and occupancy patterns. It is through this novel exploration with other occupants that new clusters of behaviors and groups emerge.

The spatial organization also affords a disposition of knowledge between visitors who have already passed though the installation chambers

Figure 2: Instruments that embody the agents, and the spatial setting for the *Perceptual Ecologies* project. Photo: Morten Hilmer.

Figure 3: Photo of interior Thingbæk limestone mine Interior. Photo: Morten Hilmer.

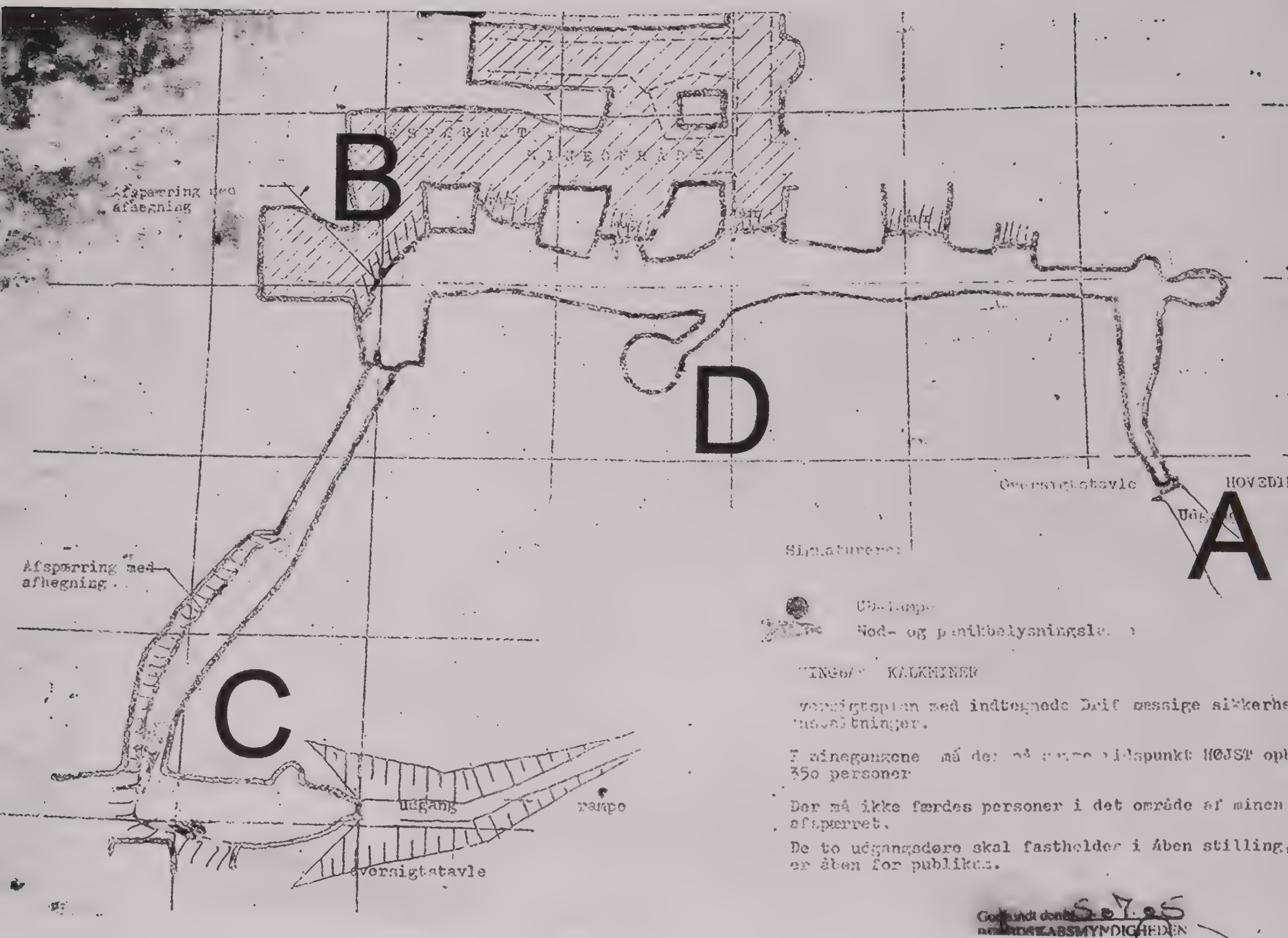


Figure 4: Thingbæk Kalkmine, an abandoned limestone mine.
Image: Esben Bala Skouboe.

and newcomers. At first, one would typically approach a sonic agent without any knowledge about interaction possibilities, and then explore the boundaries of the installation though a trial an error process, or by observing others' 'successes' and 'failures'. Through this process, one can develop a basic comprehension of the interaction logic, or simply let the experience become more familiar over time. Ultimately, the disposition of knowledge encourages interaction not just with the sonic agents themselves, but also between strangers, who may want to understand the complex interaction logics or simply engage in a manner similar to other participants. Thus, the agents became social catalysts developing a common platform for sharing of knowledge, and the exploration of the sound and the exhibition space.

The emergent and surprising musical events that could spontaneously occur when the visitor engaged – through proximity and/or creating sound themselves – allowed a series of different interactions to take place. To facilitate this situated and generative composition, which was inspired by agent-based systems in nature, we placed the individual agents into clusters (which were in turn grouped into larger colonies). In the end, the system could be described as a complete ecology with living relations between each sonic agent, as shown in Figure 5. This organization allowed the composer to address specific musical characteristics (spatial, timing of events, and 'harmony') in the different states of the complex system. It also allowed the clusters to develop situated musical outputs, thereby letting sonic agents work together in smaller clusters, where rhythms and intensities are followed to either build up or decay (in the case of 'disturbances' to the system) the musical timings of the composition, in response to each other's and human occupant(s) stimuli.

Musical composition for Perceptual Ecologies

The overall atmosphere in the cave depended on the location and actions of visitors, producing various travelling waves of audio-visual perceptual stimuli. Because the aural and spatial compositions shifted between local stimuli and larger patterns of light and sound through systemic feedback, it became a fragile negotiation between visitors and the sonic agents. The dynamic of interactions was similar to a dance performance; the occupants had to feel each other's actions and the systems responses in order to understand and influence the musical arrangement. Programming constraints for such behaviors into the system made it necessary to find a balance along the continuum from preprogrammed and directly responsive events (giving repetitive feedback) to more unpredictable adaptive events (giving perceptual complexity).

The compositional arrangement and the system's sensor inputs were merged together as simultaneous input for a 2nd-order-cybernetics inspired system. Each sonic agent functioned as a spatialized musical output controlled by the system. Since the agents communicated with

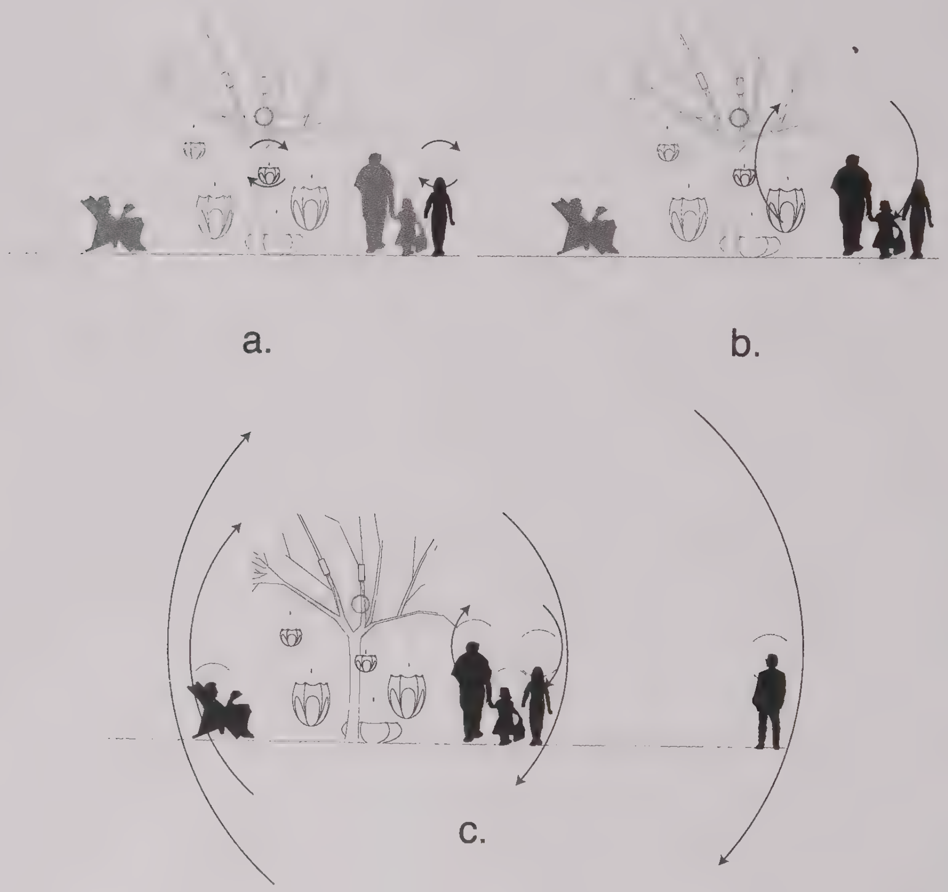


Figure 5: Diagrams showing multiple modes of interaction with the sonic agents in *Perceptual Ecologies*. Image: Esben Bala Skouboe.

their neighbors via sound (each included an embedded microphone), patterns were created in the timing of the pulses of sound, light, and wind throughout a cluster (and possibly beyond, jumping from one tree to the next). The presence of any human occupants in the cave disturbed or enhanced the system, changing the patterns and thus the overall soundscape. Spatial hierarchies would build up from individual behaviors starting with a single agent, to collective patterns in a cluster and finally into entire colonies; in the end, the whole ecology was addressed if human cooperation succeeded in promoting the traversal of sound and light behaviors from one section of the composition to the next.

To organize and structure the overall composition, a compositional curve was introduced as shown in Figure 6. The compositional curve was informed by a simple running average of the current interaction 'success criteria' in each state. As shown, the composition was divided into five different movements: Ambient (0), Acceptance (1), Play (2), Symphony (3) and Finale (4). An initial conjecture was that people would stand fairly still and together at first while observing the patterns made by the sonic agents, then notice that people can disturb the sonic and visual expressions of the agents when they become active. It was desirable to leave visitors with an impression that their actions are important, in order for them to understand their effect on the collective behaviors and the time-based evolution of the artwork.

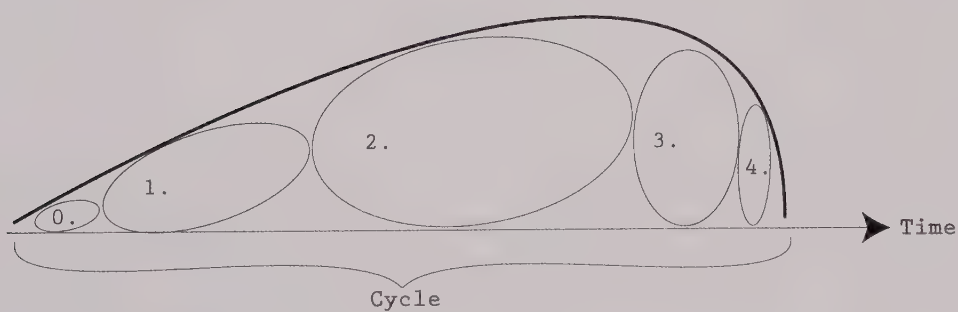


Figure 6: The five movements of the compositional curve developed for the *Perceptual Ecologies* project. Image: Esben Bala Skouboe.

To bridge the different musical states of the overall compositional curve, certain behavioral thresholds needed to be detected by the system. If the interaction during a certain phase was successful, then the system could move on to the next level; but if there was a disturbance of any kind it would decay. This type of interaction is similar to communication between many animals in nature. For example, two newly acquainted animals must understand the premise from which a gentle and abstract communication can start, allowing trust to be exchanged before a freer and more playful scenario can emerge. In Perceptual Ecologies, if sudden and large or unpredictable movement or sound events happened, a new cycle of 'trust' had to be re-established before the composition was allowed to phase into the next movement.

Ambient (0)

A default ambient mode happened only in a situation where no sensors were active. Thus, it was only possible to observe this state from a distance. Moving out of this initial state relied upon the visitors' curiosity, mobilizing attention for engagement. For the ambient mode, an organic life-like behavior was developed, in which random agents communicated with their neighbors via short light pulses and clicking sounds, not unlike the clicking of the bats living in the cave. In the background, a deep musical tone worked as a constantly pulsing drone sound, supporting a tense and mystical atmosphere. The observer was presented with a simulation of a living community of individual agents including small ultraviolet lights and short clicking sounds as a 'language' for communication between the sonic agents. The intensity of all the events in this mode was relatively peaceful.

Acceptance (1)

When a person entered the perceptual orbit of a sonic agent, the agent dimmed immediately and became 'frightened', potentially causing a wave of quietness and darkness to travel though the limestone cavern. After a few seconds, the agent closest to the 'disturbance' slowly tried to initiate communication with the stranger (participant) by gently starting the composition of acceptance. In this second mode of the composition, standing still would let the agent build up its own musical intensity, each sound agent thereby sending signals to its neighbors and eventually causing increasing intensity in the colony. The agents all mediated their own sound and light patterns, but were influenced by agents within the scale of a cluster (amounting to 10-15 sound agents, mostly constrained to those hanging in a single tree). These local dependencies caused small collective patterns of synchronized behaviors to emerge. The resulting distribution patterns eventually scaled up to the entire colony. Finally, if no interruptions were perceived by any of the sonic agents, the system evolved to the next phase, moving on to a mode for 'play'.

Play (2)

When a visitor had shown an acceptance by interacting with the prior movement in a somewhat reserved manner, the sonic agents began to initiate playful small sonic "games", which encouraged visitors to actively engage with them. Using a grid of directional shotgun microphones distributed strategically in the caves, sonic events from visitors were isolated and used to trigger samples from the microphones and play back sequences in which sounds were repeated in partially recognizable forms. This resulted in a form of imitation or 'mirroring' from the agents. The inspiration for this behavior was to have visitors contribute and invent new sounds, and investigate the acoustic properties of the space itself. It was also inspired by Steven Mithen's holistic notions about the origins of language, as stemming from things such as music, dance, and mimesis (imitation and other human and animal traits).

Symphony (3)

In the next phase of the experience, the atmosphere changed from creative, playful, and engaging to more intense, getting out of control and overwhelming. While it started from the individual agents, clusters, and colony-wide behaviors, this movement led to global spatial patterns of massive sound waves traveling throughout the cave. The composition unfolded into a collaborative sound assemblage, where all agents behaved as one sonic super-organism, similar to the emergence of collective swarm

[51] Reynolds, C.W. 'Flocks, herds and schools,' *SIGGRAPH Comput.Graph.* vol. 21, no. 4, (1987): 25-34.

behaviors described by Reynolds.[51] It is these surprising global patterns that might have triggered an awareness of strong emergent and collaborative forces in agent-based systems, and presented a collaborative and social awareness among the visitors who caused the effect.

Finale (4)

The last mode or movement – 'Finale' – led to a surprising series of events. When it began, a wave of silence spread through the cavern. Then high frequency pre-composed musical events began in spatial patterns throughout the corridors. Finally, hidden reservoirs placed in the top of the trees released a fluid that glowed underneath ultraviolet light. The lights were finally shone onto the surface of the sonic agents, no longer hiding their expressions from the visitors. During this termination of the work, the sonic agent's actuated drum-surfaces displayed complex cymatic patterns[52] in the fluid, as shown in Figure 9, reacting to the sounds they produced.

[52] Jenny (1992).

Observations

During the Perceptual Ecologies installation, a cave was temporarily turned into a kind of public 'laboratory', a space stripped of most of the familiar elements of everyday life. This unfamiliar territory caused an atmosphere in which visitors needed to reinvent their interaction rituals and re-explore the relations between their actions and the resulting effects, in order to engage with the composition. In fact, the only way to fully explore the composition was to work together with others (friends or strangers alike). Inspired by ethnographic studies conducted by the sociologist Erving Goffman, visitors were observed interacting with the various elements, and changing their behaviors when introduced to the different movements of the composition. As an initial hypothesis, it was expected that the varying levels of comprehension between newcomers and longer-term visitors would be a catalyst for social "micro-exchanges".[53] It was hoped that common goals between strangers would emerge in order to achieve evolution in the complex composition (thereby coaxing the system to move onto the next phase of the interaction).

[53] Goffman (1967).

Figure 7: Intertwined organic and technological elements of the *Perceptual Ecologies* project.
Photo: Morten Hilmer.

Figure 8: The fourth mode – symphony – of the composition for *Perceptual Ecologies*. These photographs display a global behavior, of a wave of light and activity moving towards the visitor. Photo: Morten Hilmer.

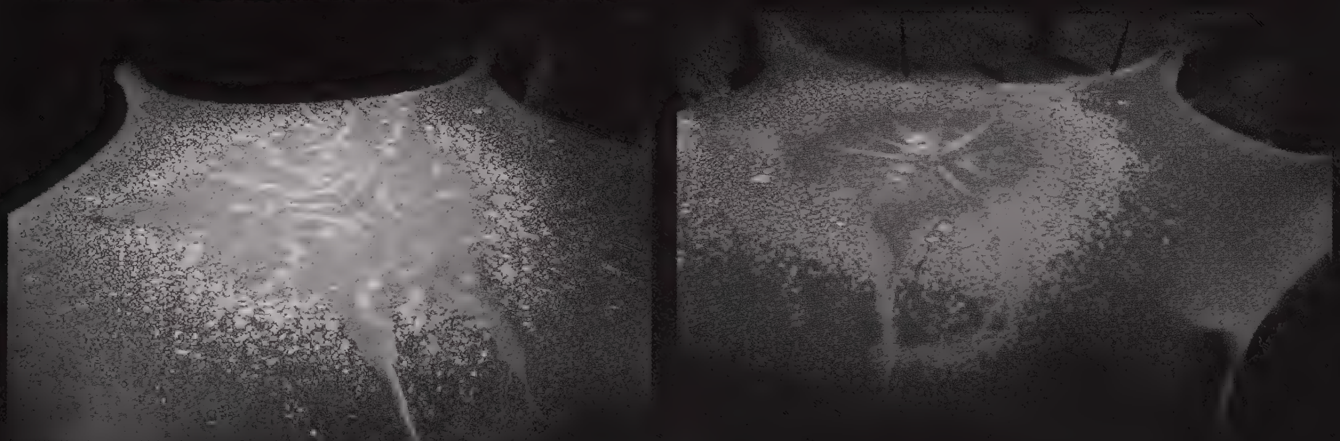


Figure 9: The fifth and final mode – finale – of the *Perceptual Ecologies* composition Cymatic patterns are materialized on the membrane of the sound agent. The patterns change according to frequencies in the sound produced. Photo: Morten Hilmer.

It was interesting to observe how people engaged in the social act of performance, especially in their interactions between one another in the cave. We observed different types of relations between visitors, such as those shown in:

- personal thoughts
- exploration of the composition together with acquaintances
- purposeful interaction with strangers while exploring in groups

The majority of visitors tended to arrive in groups of 2-6 people. Because of the cold, dark, and surrealistic atmosphere of the installation, people tended to walk very close to each other upon entering, often lowering their tone of voice. If the installation was empty when they arrived, most groups went to the middle of the trees, simply contemplating and listening to the sounds. Eventually, one or more of the group members started exploring the interaction modalities of the system, typically with gestures such as moving, touching, clapping, shouting, etc. When a person approached the electro-acoustic sonic agents in the ambient movement of the composition, he or she 'disturbed' the ecology, causing a wave of silence through the cave. In so doing, some individuals indicated (through their gestures) that they were worried that they had destroyed the experience for others. For this period of time, many groups seemed frustrated that the sound agents would not react to their behavior. However, some comments were overheard indicating notions that they felt they had 'scared' the sound agents, as if they were wild animals. When leaving the area around a tree, that colony's sound agents slowly awakened again, inviting the visitor's curiosity. It was in this phase people observed how a 'life-like' behavior unfolded in the space. However, some visitors, especially children, tended not to have enough patience to re-engage in the 'shy' sound agents interaction modality, and instead went further into the cave to explore the second chamber with different light-ventilator agents.

New groups of visitors arriving typically tried to interact with the sound agents, and after failing to activate immediate response they would observe other groups already present. People became 'performers' observed by others (audience) in their successes and failures of interacting with the system. Frustrations caused some to initiate a conversation with fellow visitors. In some cases they developed interaction hypotheses, for example: "Let's all jump at the same time, touch more than one tree at the same time etc." The exploration became a sort of collective quest for the visitors, and some groups looked for evidence of touch sensors, wires, microphones or other sensory apertures. Some of the more persistent visitors found the cameras strategically placed in dark inlets on the wall. For many, the external placement of the cameras used for tracking movement was not immediately obvious. This may have been due to the relative darkness in the cavern, and also may have been somewhat counter-intuitive, as we are accustomed to expect the ears, eyes, and mouth to initiate communication from other creatures. When the sensory organs are hidden from the center of the interaction as in this installation, it became somewhat more difficult to understand how to interact. Nonetheless, the ambient tracking technology did add a mystical dimension to the space, wherein people could perceive the feedback from the system, but they did not always know what was triggering it.

Discussion

The installation Perceptual Ecologies was not a musical concert, nor an architectural cathedral. It was an artistic experiment that explored how artists could craft a compositional system using rule-based design techniques and adaptive technologies that encourage social relationships between subjects and performing sound agents. The term 'atmosphere' was used as a conceptual frame of reference during development, and ecological metaphors were used as inspiration for complex responsive aural and visual systems. The ecological metaphor was not used to establish any 'ecological awareness' or to address environmentalism in popular culture or political responses to the crisis of human relationships with their surroundings. Instead, the ecological references were used to organize musical processes, intensities, rhythms and social dependencies in complex spatial and musical systems. More specifically, the ecological system was viewed as a living relation between the visitors and the installation, including all possible lines of communication between the included entities. Finally, the physical design (appearance) and adaptive musical composition of the work formed two key elements allowed the system to address both dynamic and static dimensions of the overall ecology. All of these elements, as well as the conceptual and theoretical tools outlined earlier have been fruitful to mediate conversations between experts in the field of architecture, music and interaction design.

Techné involves the composition of multimodal interactive experiences in which the behavior of a system can change over time through a series of adaptive modalities. The observer of such works cannot fully predict the outcome without first engaging with the system in which the experience is unfolded. As such, behavioral as well as spatial prototypes become an essential part of the artistic craftsmanship. Techné becomes a product of the artistic process between programmers, engineers, musicians and architects. Essential to this work is a common language; not a language of music or architecture, but a language of atmosphere, appearance and composition.

During a one-month exhibition more than one thousand visitors walked through the dark pathways in Thingbæk limestone mine. The visitors consciously or sub-consciously presented stimuli to the complex composition, and the instruments responded with audiovisual outputs that were part of the multilayered generative composition. This in turn affected how the work was perceived by the visitors, and stimulated neighboring instruments, presenting partially self-organizing sound patterns, such as traveling waves of sounds and light moving though the space. Sonic intensities emerged, and every instrument reacted with rapid response patterns in relation to external stimuli somewhat like the intricate patterns of birds in a flock. One of the most important elements of the system was that larger global behaviors could develop from small local events between people and the ecology. During the exhibition the artists were sitting on the side observing how curious people engaged with the lifelike aesthetics and through a series of interaction attempts investigating the generative compositions. Often people began creating their own conjectures and even names for the sonic agents – children asked their parents, and grown-ups observed and asked each other about the behavioral patterns. The perceptual ecologies installation did in fact afford new meetings across social groups of strangers, friendships and family.

Towards Probabilistic Worldmaking: Xenakis, n-Polytope and the Cybernetic Path to Chaos

Chris Salter and Sofian Audry

Bursts of light that ricochet through space producing spirals, circles, lines. Sonorous densities assembled out of hundreds and thousands of tiny, grain like events; starting, stopping, moving at different speeds, intensities, densities, rhythms. Ephemeral forms. Latent trajectories. Thousands of tiny sonic and luminous events that cannot be perceived individually but only as a whole. The laws of groups and masses. "The statistical laws of these events, separated from their political or moral context, are the same as those of cicadas or rain. They are the laws of the passage from complete order to total disorder in a continuous or explosive manner. They are stochastic laws."[1]

[1] Iannis Xenakis. *Formalized Music: Thought and Mathematics in Music.* New York: Pendragon, 1992, 9.

The artistic work of Iannis Xenakis, the Greek born, French exiled polymath who trained in civil engineering and music and fluently moved among architecture, acoustics, philosophy, technology, and aesthetics, would at first appear and sound like something deeply rooted in its time: the post-war ruins of Europe and the countercultural explosion of 1950s -1960s in which the artistic avant-garde raised its flag of defiance at old hierarchies, structures of power and the ossified socio-politico-cultural systems that lead to fascism on one side and Stalinism on the other.

That Xenakis could compose music in which "you're confronted with an aesthetic that seems unprecedented according to any of the frames of reference that musical works usually relate to," is deeply rooted in the composer's own direct, lived encounter with the savagery of World War II's devastation and his resistance to it.[2] The almost cosmological immensity of the destruction from the war infects almost every aspect of Xenakis's artistic worldview, from his own direct bodily experience of losing an eye in a blizzard of shrapnel blasts to the witnessing of the spectacular ruination of Athens in spectacle-like proportions, described in the epigraph above. Such implacable, ferocious images and sounds continually infuse the composer's works in the most varied of ways: the dense cacophony of glissandoing strings in his first major work, *Metastasis* (1953-54); the searing granulation of crackling, burning charcoal that makes up the only sound source of *Concret PH* (1958), Xenakis's composition for the entranceway of the Philips Pavilion (1958); the bursting, pointillist mass of stroboscopic lights that constitute the visual *mise en scene* of the multimedia *Polytope de Montréal* (1967) and *Cluny* (1972) spectacles, and the

[2] Tom Service. "A Guide to Iannis Xenakis's Music." *The Guardian*. April 23, 2013.

parades of fire and searchlights of the *Polytope de Persepolis* (1971) and *Polytope de Mycènes* (1978). Even Xenakis's unrealized projects such as plans for an interstellar "World Polytope" that would use a network of lasers and satellites bouncing beams to and from the earth bear traces of the composer's early life experience.[3]

[3] Xenakis, Iannis (2008) *Music and Architecture*. Ed and Trans. Sharon Kanach) (annotated edition). Hillsdale, NY: Pendragon Press. 254.

[4] Ben Watson. "Iannis Xenakis." *The Wire*. Issue 136. June 1995.

Yet, how did music, and indeed art of such primal ferocity, of "truly majestic *otherness*," emerge?[4] What techniques did Xenakis employ to place listeners in a vertiginous relationship to sound, where the determinism of serialism and its methods of linear composition gave way to a sonancy forever moving on a continuum between order and disorder, apparent randomness and structure? Perhaps more relevant to the concepts of how *techné* facilitates worldmaking and worldmaking acts as *techné*, how do these works and in particular, the Polytopes, Xenakis's own attempt at the elusive Wagnerian *Gesamtkunstwerk* built with the scientific and mathematical techniques of the composer's time stand up in our current technoscientific-cultural moment and how might they be reimagined?

This question of how and through what means we can understand the Polytopes, the neologistic name Xenakis gave to the immersive light, sound and architectural environments he developed in international locations between the years of 1967-1979, is what motivates this study. What we propose here is not a purely musicological or historical discussion. Rather, in this essay, we trace two intertwined and overlapping arcs: one aesthetic/conceptual and the other techno-scientific. We examine a recent attempt to reimagine the Polytopes in an age of ubiquitous computing and networked culture undertaken with a team of artists, technologists and architects between 2011-2013.[5] Dubbed *n-Polytope: Behaviors in Light and Sound after Iannis Xenakis*, the project, according to the press release, "is a spectacular light and sound performance-installation combining cutting edge lighting, lasers, sound, sensing and machine learning software inspired by composer Iannis Xenakis' radical 1960s-1970s works. *n-Polytope* is based on the attempt to both re-imagine Xenakis' work in probabilistic/stochastic systems for composition with new techniques as well as to explore how these techniques can exemplify our own historical moment of extreme instability."[6]

[5] The artists included Chris Salter (concept/direction), Sofian Audry (Media Behavior Modeling and Programming), Marije Baalman (Embedded Systems, Micro Light and Sound Design, Media Composition Programming), Adam Basanta (Co-Composition), Elio Bidinost (Lighting and Laser System Design) and Thomas Spier (Architectural Design).

[6] Salter, Chris (2012) "N-Polytope." In *Xenakis Matters: Contexts, Processes, Applications*. Ed. Sharon Kanach. New York: Pendragon, 411-412.

Just as Xenakis' own artistic work is entangled within larger aesthetic, philosophical, socio-technical and techno-scientific questions, so too is our own attempt to render the spirit, if not the letter, of Xenakis' vision some forty-seven years later through contemporary techniques. As large scale, immersive architectural environments that made the indeterminate patterns and behaviour of natural phenomena experiential through the temporal dynamics of light and the spatial dynamics of sound, the Polytopes to this day are still relatively unknown but can be seen as a major landmark in the history of immersive audio-visual arts as well as what is currently termed interactive or responsive architecture. But these multi-mediated environments are also exemplary of the kind of processes that Nelson Goodman articulates in his *Ways of Worldmaking* (1978): division, composition, weighing, ordering, distorting and interpolating. Such processes, which Goodman described as "the ways that worlds are made" indeed function as techniques or *techné* in themselves that contribute to the making of worlds from other worlds "already on hand" - a "remaking," as Goodman terms it, of art from scientific or cosmological principles.[7]

[7] Goodman, Nelson (1978) *Ways of Worldmaking*. Indianapolis: Hackett Publishing Company, 6-13.

The Aesthetics of Totality: *The Polytope de Montréal*

Like many of his purely musical works, the Polytopes' telos continues Xenakis's aesthetic, conceptual and scientific trajectories: interest in the behavior and dynamics of scientific phenomena as a microscopic portrait of macroscopic systems and assembling techniques for exploring the space of continuous versus discontinuous transformations as well as the continuum between order and disorder. Yet, by virtue of their theatrical, "total artwork"-like status, an emphasis on elements such as light combined with sound and site specific architecture and the participatory role played by spectators, the Polytopes are also a different kind of project for Xenakis as compared to his compositional work.

In a general sense, the Polytopes were a partial response to Xenakis' work on the Philips Pavilion in collaboration with Le Corbusier in 1958 and, in particular, the master architect's design of the projected images in the pavilion which Xenakis later critiqued in his 1958 text "Notes Towards an Electronic Gesture." While Xenakis' hyperbolic paraboloid architectural exterior formed from mathematical models called S-curves is well understood, less well known is the audio-visual media environment set up within the interior - Le Corbusier's "Poème Electronique" and Edgar Varese's similarly titled multi-channel tape composition. Le Corbusier's visual counterpart to Varese's music consisted of an eight-minute light show together with a film of sequenced photographs shot and edited by the acclaimed cinematographer Philippe Agostini, whose narrative loosely "tells the history of humankind in seven sections." Projected directly onto the hyperbolic ruled surface walls of the pavilion, Le Corbusier's visual *mise en scene* was later highly criticized by Xenakis who argued that the architect's use of the cinematic image could not go beyond the rectilinear frame; "the screen hole or projection window" which stranded the image within a flat, 2-D horizontally and vertically defined space.[8]

[8] Iannis Xenakis. 1958. "Notes towards an Electronic Gesture." In *Xenakis: Music and Architecture*. Ed Sharon Kanach. New York: Pendragon, 2008, 131-134.

Instead, Xenakis suggested the transformation of image in relationship to sound through the proposal of new kinds of geometric spaces that could warp, shift, and mutate the image into "a new architectural concept that will emerge from the beaten path of the plane and right angle in order to create a space that is truly three dimensional."[9] Indeed, within Xenakis' assertion in his 1958 essay "Towards an Electronic Gesture" that a "new conceptual consciousness, abstraction and a technical infrastructure, electronics" could result in further experiments "in the artistic synthesis of sound, light and architecture," (represented first by the Philips Pavilion) one can already see the groundwork being laid for the first Polytope, the *Polytope de Montréal*, realized almost ten years later within the site of the French pavilion in the context of Expo '67.[10]

[9] Ibid, Xenakis. 132.

[10] Ibid, 134.

Originally termed an "electronic sculpture combining light, music and structures," the *Polytope de Montréal* emerged from a commission by Robert Bordaz, the curator of the French pavilion. Proposing a performance event consisting of an "interplay between light and sound through the available space and automated by computers," Xenakis' performance environment consisted of a similar hyperbolic geometry as the Philips pavilion; a Naum Gabo-inspired "transparent architecture" constructed from 200 gigantic steel cables, in lengths ranging from 21-30 meters and tautly stretched through the inner atrium of the French pavilion. Divided into five groups, each bundle of cables formed a ruled surface and was instrumented with what Xenakis called "thousands of light sources" split in a corresponding set of five families of color: white, blue, red, green and yellow.

Although Xenakis originally imagined a sonic accompaniment consisting of four separate live acoustic ensembles, budgetary and logistical constraints forced the musical score to be pre-recorded and played back over four separate channels of speakers within the space. In contrast to the staccato, bursting "stop and go" quality of the light spectacle, Xenakis' six-minute long, purely instrumental score sought to reinforce the continuous: continually in motion glissandi; sudden *szforzando* accents; a "sound that changes but never stops."[11]

[11] Xenakis, In Kanach 2008, 214.

While sound continually occupies Xenakis' attention, it is his almost obsessive attention to light, from the bursting pointillist formations inherent to the *Polytope de Montréal* and the projective geometries of the lasers that form the *Polytope de Cluny*, to the outdoor processions of torches, fireworks and searchlights that mark the *Polytope de Persepolis* for the Shiraz festival in Iran in 1970 and the later *Polytope de Mycènes*, which strongly guides the evolution of the Polytopes. Xenakis states as much when he makes the somewhat peculiar claim that the Polytopes were artistic environments that would create two kinds of music, "one to be seen and one to be heard" and that while the music would emphasize spatial aspects of the work, light would explore the temporal side.

Even with his attempt to emphasize a strong split between the temporal and spatial aspects of media, Xenakis' approach to light in the *Polytope de Montréal* similarly follows his earlier conceptual and technical trajectories. Utilizing aspects of the mathematical theory of groups as well as set theory, Xenakis resorts to compositional strategies based on logical operations that partially determine the temporal and spatial sequence of lighting events. For example, through the use of logical operators (addition, concatenation, conjunction or disjunction, complementary actions, Boolean structures) Xenakis creates different, interpenetrating rhythms for the lights, such that "rhythms begin to create patterns and then permeate each other. Subgroups appear as well as rhythmic invasions by groups, all to create a first general rhythmic pattern."[12]

[12] Ibid, 213.

The mathematics of sets function here as both an organizing principle and method to generate patterns and sequences among a mass of similar objects over different spatio-temporal scales. In this way, light no longer operates as a kind of fixed scenic element that produces key and fill areas but, following Xenakis' interest in the aggregate behavior of natural phenomena like clouds or cosmological events, as a series of individual particles within a larger mass whose behaviors in terms of density, speed, duration, rhythms and overall dynamics can be controlled and modulated by general statistical laws.

This interest in a "multitude of sounds" as textural aggregates where the movement and shape of the whole is more important than individual parts or series, acts as one of the cornerstones in Xenakis' approach to composition and is articulated early on in his critique of the stultifying musical trend of his time: the almost ideological reign of Post-War serialism which had seized the musical avant-garde.

In direct contrast to the *Musique concrète* work of Pierre Schaeffer and Pierre Henry, which explored the manipulation of found sounds, the European and American avant-garde led by Pierre Boulez and Karlheinz Stockhausen on the European side and Milton Babbitt on the American, whole-heartedly adopted serialism: "applying the pitch operations of the twelve tone system to non-pitch elements: durational rhythm, dynamics, phrase rhythm, timbre and register, in such a manner as to preserve the most significant properties associated with these operations in the pitch domain when they are applied in these other domains."[13]

[13] Paul Griffiths. *Modern Music: The Avant Garde Since 1945*. New York: George Braziller, 1981, 38.

But such deterministic "linear polyphony" with its overreliance on mainly pitch-based "combinatory tricks" and "strict, deterministic causality" as Xenakis phrased it in his searing, 1955 manifesto-like "The Crisis of Serial Music" published in the music journal *Gravesaner Blätter* yielded a music of stasis and non-movement; one which "destroys itself by its very complexity; what one hears is in reality nothing but a mass of notes in various registers."[14] It is this uprising against determinism, the critique of the "linear category" in musical thought through which Xenakis sought a wholly different direction for artistic production and experience through the scientific and mathematical techniques of his time. "Obliterating the abstractions of the musical avant-garde" (Harley),

[14] Xenakis 1992, 8.

Xenakis worked to organize and create compositions principally through the laws of *probability* which he labeled "stochastics."[15]

[15] James Harley. *Xenakis: His Life in Music*. New York: Routledge, 2004, 6.

A Probabilistic Worldview

What did harnessing probability as a compositional tool give Xenakis that the combinatorial structures of serialism did not? Already Xenakis declared the "poverty of 'combinatory' thought in music" during his early studies of music while studying engineering.[16] As Xenakis's biographer Nouritza Matossian describes, serialism is based on the continued re-arrangements and permutations of original patterns - in this case, the twelve tone system.[17] The "perceptual ability of the ideal listener may be to recognize the original series and then compare it with permutations and subsequent variations in other parameters, such as duration, dynamics and so on."[18]

The problem, however, lies in the fact that in order to recognize such permutations from the original series, time must be perceived as an atemporal totality in which one can see all of the patterns and variations simultaneously, something that painting with its principle of presenting the whole work at once enables, but music with its temporal unfolding does not. "Hence one of the essential features of music, movement in time, is inaccessible to serialism."[19] In fact, Xenakis calls illusory the idea that something of more sophisticated musical complexity and richness could arrive from combinatoric procedures.

In contrast, the use of probability functions or "distributions" (an equation that links each outcome of a statistical experiment with its probability of occurrence)[20], Xenakis argues, could produce "very free paths which never repeat themselves and which correspond to much richer melodies and sounds."[21] Probability models give the potential of unexpected outcomes which "are not periodic and not mechanical."[22] Moreover, the application of probability functions is one of the chief components of stochastic systems in which the behavior of individual components is not necessarily based on causally determined laws.

One such model Xenakis extensively draws on, no doubt based on his training in engineering and exposure to the science of statistical mechanics,

[16] Noritza Matossian. *Xenakis*. Damascus, Cyprus: Moufflon, 2005, 21.

[17] The twelve tone or dodecaphonic system consists of "music based on a serial ordering of all twelve chromatic pitches. The series of twelve pitches (also known as the row), whose form is uniquely determined for each composition, serves as the referential basis for all pitch events in that composition." See Randel (ed), 1986, 886-889.

[18] Matossian, Nouritza (2005) *Iannis Xenakis*. 2nd edition. Lefkosia, Cyprus: Moufflon, 18.

[19] Ibid, 98.

[20] http://stattrek.com/probability-distributions/probability-distribution.aspx. Accessed April 27, 2016.

[21] Iannis Xenakis. *Arts/Sciences:Alloys*. Trans. and Edi. Sharon Kanach. New York: Pendragon, 1985, 37.

[22] Xenakis, Iannis, Volker Banfield and Heinz Otto Peitgen. "Iannis Xenakis (1 of 2) Filmed Interview." Youtube, n.d. http://www.youtube.com/watch?v=j4nj2nklbts&feature=related (accessed March 1, 2011).

is the behavior of gas molecules. In his 1956 composition *Pithoprakta*, the first to use stochastic methods, Xenakis deploys the Maxwell-Boltzmann distribution based on the kinetic theory of gasses which models the speed density of gas particles in accordance with the temperature of a given system. In the composition, gas particles are replaced by *pizzicato glissandi* whose steepness corresponds to the velocity sampled from the random distribution, resulting in a cloud of swarming sounds filling the air.

Xenakis' interest in stochastic systems applied to musical structures leads in several directions. On the one hand, applying probability distributions can only be done with a sufficiently large sample, such as a mass of particles or a cluster of multiple pitches. This use of probability distributions is in line with Xenakis' interest in the non-causal behaviors among individual components within masses and aggregates; "clouds of sound" over singular melodic lines. But following classical thermodynamics, Xenakis works at both the micro and macro levels of a system, his main goal being to explore the *entropic characteristics of a system's behavior* which, within a thermodynamic context, represents the degree of *disorder* in the system.[23] Indeed, returning to Boltzmann, Xenakis' notion of the order and disorder continuum is captured by the argument that the latter is defined by the increased randomness or probability within that system *at the microlevel*.

[23] Recent work in thermodynamics within chemistry has attempted to discuss the notion of dispersal over the concept of disorder.

On the other hand, Xenakis searches for what is known in statistics as *rare events*. He seeks to harness the potential of particular probability distributions, such as the Poisson distribution which mathematically models the probability that a given number of events occur in a specified time interval, to generate "highly improbable events" that can produce "explosive" deviations from the mean, resulting in a sudden shift from order to disorder.[24]

[24] Xenakis, 1985, 16.

Xenakis' use of probabilities has been extensively described in the musicological literature[25] but what the deployment of these stochastic laws accomplishes is to provide a method for Xenakis to generate compositions out of indeterminate systems, extirpated from human control, while still being able to respond to the macroscopic rules that make such systems appear determinate at the macro level; that is, statistically predictable. Sounds are thus distributed across radically dynamic spatio-temporal

[25] See Xenakis 1985; 1992 and Matossian for further descriptions.

shapes: masses, clouds, densities in which it is impossible for the listener to experience and follow any individual element and where s/he must plunge herself into the structure and pattern of the aggregate.

As an approach to worldmaking, however, Xenakis' application of probability results in something with far greater consequences than just a pool of sophisticated techniques for musical composition. Similar to Andrew Pickering's discussion of the performative aspects of science, Xenakis' deployment of probability and other mathematical techniques is not meant to create representations or mirrors of mathematical phenomena but rather to construct a system for the generation or performance of potentially unpredictable sonic behaviors.[26] While one might be tempted to argue that the combinatorics of serialism do the same thing using combinatorial procedures to produce a certain type of music that constructs its own world, what is at stake here is the kind of phenomena and hence, world that is *produced* and performed based on Xenakis' choice of probability models. In other words, a different world for the composer-perceiver arises from the choice of a model utilizing serialist procedures - in which variations take place but essentially never alter the original phenomena - to one which generates a world of micro and macro behavior; of the continuous movement between order and disorder over different spatio-temporal scales.[27]

[26] According to Pickering, in contrast to the representational view of science which "casts science as, above all, an activity that seeks to represent nature, to produce knowledge that maps, mirrors or corresponds to how the world really is," the "performative image of science" is where science is "regarded as a field of powers, capacities, and performances, situated in machinic captures of material agency." See Pickering 1995, 5-7.

[27] See Bricmont, Jean (1995) "Science of Chaos or Chaos in Science?" *Annals of the New York Academy of Sciences* 775 (1): 131–75.

Feedback, Self-Regulation and Information

The question of statistical predictability, and the role that probabilities play in the enaction of order and disorder is deeply rooted in the scientific paradigms of Xenakis's time: statistical mechanics and information theory. What lurks in the shadows and is brought up in an inconsistent and mostly sporadic manner in Xenakis' own writing, however, is the position occupied by that other reigning scientific theory of the time, cybernetics. Although scattered references to cybernetics occur in a range of Xenakis' writings, he appears to have a selective reading of cybernetic principles, focusing primarily on the stochastic and information theory side of things but leaving the central concepts of negative feedback, system self-regulation and complexity, as defined by the founder of cybernetics, mathematician Norbert Wiener, mostly untouched.[28] Ironically, while other composers

[28] Examples of cybernetics in Xenakis's writings include "Towards a Metamusic" in *Formalized Music* and scattered references in *Arts/Sciences: Alloys*.

like John Cage or composers who turned towards the visual arts like Nam June Paik were, during the same period inspired by Wiener's writings and exploiting these concepts by building sensor-augmented, electronically driven systems for the manipulation of sound and image, there is barely any evidence in the existing posthumous corpus of Xenakis' writings to indicate an interest in questions concerning the *behavior* of cybernetically influenced systems.[29]

Driven by his education as an engineer, Xenakis was operating with and using mathematical systems inspired by the statistics of thermodynamic systems. One of the building blocks of statistical mechanics heavily employed by Xenakis is the concept of *entropy*, which represents the degree of disorder within a system. Interestingly, entropy is also a foundational concept of Claude Shannon's information theory. Trained in mathematics and engineering, Shannon had worked as a cryptographer during World War II. In his 1948 seminal Bell Labs technical report, "A Mathematical Theory of Communication"[30], Shannon establishes a clear separation between a message and the signal that encodes it. In a now almost infamous but much misunderstood pronouncement, Shannon declared that the *meaning* conveyed by a message is "irrelevant" to the engineering problem.[31] The engineering problem of communication should instead be concerned with the *probability* of appearance of one message over another.

Shannon thus formulates the basic problem of communication as the transmission of a message from one point to another through a potentially noisy channel, in which information is in fact a *quantity* that corresponds to the minimum number of bits needed to encode the message. Showing how highly predictable messages can be encoded using fewer bits of information than unpredictable ones, Shannon relates the information conveyed to its degree of unpredictability, which is mathematically equivalent to its entropy.[32]

The elegance of Shannon's model, its strong mathematical grounds and immediate applicability in the communication technology of the time are all responsible for its success and impact on dozens of fields ranging from neuroscience and cryptography to quantum physics and digital signal processing. Indeed, the model became so pervasive that it led to the

[29] Edward Shanken has argued that "cybernetics and art must be understood in the context of ongoing aesthetic experiments with duration, movement, and process" (Shanken 2003) which is one ground for the interest in the burgeoning interest in art and technology in the 1960s. Examples include the work of expanded cinema, USCO, Cage and Cunningham's early work with sensing systems and two major exhibition and performance events of the1960s: *9 Evenings: Theater and Engineering* initiated by Bell Labs engineer Billy Klüver and Robert Rauschenberg in 1966 and Jasia Reichardt's exhibition *Cybernetic Serendipity* at the ICA London in 1968. See Shanken, Edward A. (2003) "From cybernetics to telematics: the art, pedagogy, and theory of Roy Ascott." In *Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness*. Berkeley: University of California Press, 21-23.

[30] Shannon, C. E. (1948) A Mathematical Theory of Communication. *Bell System Technical Journal*, *27*(3), 379–423.

[31] Ibid. 379.

[32] H(X)=-sum_(x)P(x) log_2[P(x)] bits, where P(x) is the probability that X is in the state x, and Plog_2P is defined as 0 if P=0.

development of the entirely new field of information theory, disguising the immensely reductive character of its definition of information and the fact that, from the cybernetics perspective, Shannon's model was only a small part of the larger context of what information could be and what significance it could have.

Information and statistical mechanics also play a central role in Norbert Wiener's development of cybernetics, particularly in the mathematician's linking of research into his "AA" anti-aircraft predictor fire control apparatus for surface-to-air ballistic defense ("a mechanico-electrical system which was designed to usurp a specifically human function [...] and forecast the future") together with the control engineering concept of negative feedback and the operation of such feedback across human mechanisms, such as involuntary and voluntary behaviors in the nervous system.[33] Indeed, Wiener argues that control and communications engineering are united by the common framework of messages, regardless of whether such messages are transmitted by "electrical, mechanical or nervous means." By focusing on the message ("a discrete or continuous sequence of measurable events distributed in time") as a phenomena in time whose future can be predicted probabilistically, Wiener thus proposes a statistical approach to problems of communication engineering. "The notion of statistical mechanics has indeed been encroaching on every branch of science for more than a century [...] in the case of communication engineering, however, the significance of the statistical element is immediately apparent. The transmission of information is impossible save as a transmission of alternatives."[34]

Yet, in his definition of cybernetics, Wiener not only refers to Shannon's concept of information, which stays in the purely syntactic realm, but also to the semantic aspects of messages and their potential role in the control and regulation of machines, humans and society.[35] In fact, in 1946 Wiener coined the term cybernetics in reference to an 1868 article on feedback regulation mechanisms in governors[36] from James Clerk Maxwell, the physicist at the origin of the theory of gasses. As Wiener wrote, "We have decided to call the entire field of control and communication theory, whether in the machine or the animal, by the name *Cybernetics*, which we form from the Greek *kubernetes*, or steersman. In choosing

[33] See Galison, Peter (1994) "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision." *Critical Inquiry* 21 (1): 228–266.

[34] Wiener, Norbert (1961) *Cybernetics or Control and Communication in the Animal and the Machine*. Vol. 25. Cambridge, MA: MIT Press, 10.

[35] Smith, August W (1974) "Information Theory and Cybernetics." *Journal of Cybernetics* 4 (3): 1–5, 2.

[36] Maxwell, J. Clerk (1867) "On Governors." *Proceedings of the Royal Society of London* 16 (January): 270–83, 270.

this term we wish to recognize that the first significant paper on feedback mechanisms is an article on governors, which was published by Clerk Maxwell in 1868, and that *governor* is derived from a Latin corruption of *kubernetes*."[37]

If Wiener was interested in Shannon's theory because it provided a probabilistic framework for understanding how messages circulate between a system such as the brain and its environment, he was even more taken by how such systems would engage in a self-regulating exchange with their environment in order to attain their goals. In this context, information acts as an active code that takes part in a control loop between a purposeful system and its environment. In their initial states, such systems are highly entropic: information flowing through negative feedback introduces a "degree of order (control)" since "information reduces uncertainty and contributes to order."[38] In other words, entropy acts as the central linkage between information and statistical mechanics. "Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other."[39]

Xenakis was eager to adapt information theory to musical composition and, along with other cybernetics-influenced researchers and composers including the French sociologist Abraham Moles, Michel Philippot and Alain de Chambure, helped form the informal research group MYAM.[40] Xenakis even goes as far as to claim that cybernetics was a key influence on his musical thinking in a 1957 letter to conductor and Xenakis promoter Hermann Scherchen, claiming that through his use of transformations ("the basis of cybernetics") in *Metastasis* the composer "was doing cybernetics" without knowing it.[41]

But Wiener's other key cybernetic concepts of behavior, feedback and self-regulation seem to be mostly missing from Xenakis' corpus of works and practice.[42] In fact, as historian of science Steven Heims argues, despite its interdisciplinary origins, one of the core principles that held cybernetics and "the cyberneticians" together was the emphasis on the behavior of organisms in relation to machines as well as the replacement of "traditional cause-and-effect relation of a stimulus leading to a response by a 'circular causality' requiring negative feedback."[43] In point of fact,

[37] Wiener, Norbert (1961) *Cybernetics: Or Control and Communication in the Animal and the Machine.* MIT Press, 11-12.

[38] Smith 1975, 3.

[39] Wiener 1961, 11.

[40] See Solomos, Makis (2006) "The Granular Connection (Xenakis, Vaggione, Di Scipio...)."*Symposium The Creative and Scientific Legacies of Iannis Xenakis International Symposium*, Canada.<hal-00770088>

[41] Xenakis, I. (1957) Letter to Hermann Scherchen of 19 December 1957, Archives Xenakis, National Library of France; as found in M. Solomos, 'Les «operations mentales de la composition » (Xenakis)', *Intellectica*, vol. 48-49; issue 1-2; 2008; electronic version <hal-00770202>., 208.

[42] Touloumi, Olga (2012) "The Politics of Totality: Iannis Xenakis' Polytope de Mycènes." In *Xenakis Matters: Contexts, Processes, Applications.* Ed. Sharon Kanach. New York: Pendragon.

[43] Heims, Steve Joshua (1993) *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946-1953.* New edition. Cambridge, MA: MIT Press, 15-16.

the inaugural meeting of the famous Macy Conferences held in New York from 1946-1952 was entitled "Feedback Mechanisms and Circular Causal Systems in Biology and Social Sciences."[44]

While concepts of feedback, self-regulation and circular causality - the idea that an action at one point in time acts as input for an action in the future - curiously seem to be lacking in Xenakis' approach to the design of probabilistic compositional worlds, there are a few exceptions, particularly in some of his later algorithmic-based music compositions.[45] For example, in works like *Ata* and *Horos* stemming from the 1980s, Xenakis deployed a self-regulating, self-organizing system known as *cellular automata* to produce the scores and perform the results.[46] First defined in the 1950s by John von Neumann[47] and extensively studied in the 1980s by researchers like Christopher Langton[48] and Stephen Wolfram,[49] cellular automata are "discrete dynamical systems with simple construction but complex self-organizing behaviour."[50]

We can only conjecture as to the reasons behind the relative absence of such autonomous systems in Xenakis' work up until the 1980s. A logical explanation would come down to a question of means and intentions. Xenakis was not a scientist: he was an artist who used science and mathematics as a means to aesthetic ends. Furthermore, although the concepts of feedback and self-regulation were an important part of cybernetics and many scientists of his time worked on self-regulated and self-organizing systems, such work had been limited until the 1980s to very simple, "toy" systems with a relatively low number of components, such as Grey Walter's tortoises and Ross Ashby's homeostat.[51] Such simple systems seem to be at complete odds with the kind of artistic totality Xenakis sought in both his compositions as well as in his architectural-media environments like the *Polytopes* and the *Diatope*, involving mass elements in the form of light, mirrors, lasers, speakers, etc. Even more, during Xenakis' most active period in the 1960-70s, symbolic, heuristic-based AI flourished while self-organizing systems were relegated to the background. In the 1980s, the failure of such general problem-solving and symbolic-based systems, the discovery of new algorithms and the increase in CPU power allowed self-organizing systems to return to research agendas in complexity theory, chaos theory, non-linear dynamical systems, artificial life and machine learning.

[44] Ibid 17.

[45] According to Touloumi, Xenakis did exploit some positive/negative feedback models in his 1962 composition *Strategie* in which two orchestras duel with each other.

[46] Solomos, Makis (2005) "Cellular automata in Xenakis's music. Theory and Practice." *International Symposium Iannis Xenakis*. Athens, May.

[47] Von Neumann, John (1966) *Theory of self-reproducing automata*. Ed. Arthur W. Burks. Champagne-Urbana: University of Illinois Press.

[48] Langton, C. G. (1984) "Self-reproduction in cellular automata" *Physica D: Nonlinear Phenomena, 10*(1–2), 135–144.

Langton, C. G. (1986) "Studying artificial life with cellular automata." *Proceedings of the Fifth Annual International Conference, 22*(1–3), 120–149.

[49] Wolfram, Stephen (2002) *A New Kind of Science*. Champaign: Wolfram Media.

[50] Wolfram, Stephen. 1984. "Universality and Complexity in Cellular Automata." *Physica D Nonlinear Phenomena* 10 (January): 1–35.

[51] Not all cybernetic systems were as simple as Ashby's or Grey Walter's. For example, Gordon Pask's *Musicolor* instrument (1953) and his media environment Colloquy of Objects (1968) were complex systems utilizing multiple components. See Pickering 2010 for further description.

There is another potential reason. According to Xenakis specialist Makis Solomos, the composer's idea of automata is related to Wiener's concept of *autonomy*, a vision that emphasizes the self-organization of a system, as opposed to the *command* perspective of von Neumann which is rather linked to a militaristic, "black box" model of machinic control. Xenakis, however, does not fully endorse the idea of autonomy, instead seeming to be interested in using cellular automata as a tool to help shape his compositions but over which he still maintains control. "Xenakis' manual interventions are very important; sometimes they destroy the nature of cellular automata. And, of course, they are far away from the idea of something that works alone, of an automaton, from which an autonomous meaning emerges."[52]

[52] Solomos, 2006, 16.

Moreover, Xenakis uses the computer in his work mainly as a control system to generate sonic and visual morphologies but not necessarily as a way to produce unexpected temporal behaviors. This is in stark contrast to Xenakis' fellow composer John Cage, who used feedback systems in his work due to his interest in the conceptual possibilities of autonomous systems to remove the composer and the composer's intention from the process of creation.

N-Polytope 2012 - Machine Learning, Agency and Self-Organization

Jump forwards to 2012. We began this essay by asking what Xenakis' vision of the Polytopes could be in our current technical-historical moment: an age of ubiquitous computing and networked culture in which the ideas of self-regulation, organization, complexity and feedback that were posited as the holy grail of the first wave of cybernetics have now been deployed in almost every aspect of social-technical-aesthetic life. Cybernetics might have disappeared off the research radar screen in favor of symbolic AI and the reign of extreme representationalism in cognitive science in the 1960-1970s, but we only have to look at how AI is currently defined to see how issues of self-organization, circular causality and control return with a vengeance.[53]

[53] As a 2012 mass enrolled online AI class at Stanford University taught by former director of research at Google Peter Norvig and one of the foremost AI researchers Sebastian Thun: "the big question about artificial intelligence is the function that maps sensors to actuators that is called the control policy" of an agent interacting within an environment.

In beginning work on *N-Polytope* under a larger research project focused on emergent systems utilizing large scale sensor networks, we reflected on how Xenakis might have reacted to our current rapidly transforming scientific and technical milieu and its relationship to new artistic practices. In fact, given Xenakis' enthusiasm for stochastic processes due to his interest in the behavior of natural phenomena, we speculated that the composer might have become more attentive to the behavioral and complexity dimensions of cybernetics and not only to its information theoretic aspects. Hence, from an aesthetic-technical perspective, rather than thinking in terms of global effects and densities happening at the macro level, our approach was guided by imagining a Polytope where movements emerging from groups of individual agents could act at the microscale and behave according to local rules.

Originally developed and produced at the LABoral Centre for Art and Industrial Culture in Gijon, Spain in July 2012, the scenography of *N-Polytope* consists of 24 steel cables with LEDs and small, 1W speakers. The cables form a customizable topological surface that is adapted to each venue. 12 of these cables each feature four custom 3-D printed containers which hold electronics including the LED drivers, a wireless microcontroller/transceiver[54] as well as the speakers. Each of these controls three 10W LEDs (light) contained in small aluminum housings and one speaker (sound) and can observe data about their surroundings by way of a series of three photocells (light) and a microphone (sound). These nodes can be controlled either individually, as a group, or as sub-groups. A total of 48 nodes can thus be activated simultaneously, controlling up to 144 LEDs in total across the twelve cables using pulse-width modulation.

[54] http://sensestage.hexagram.ca/ Accessed April 28, 2016.

Experientially, while the behavior of the LED's create a changing space of bursting points, coloured lasers that bounce off the surface of mirrors generate fleeting architectures of lines and shapes that flicker and disappear before the visitors' eyes.[55] Counter-pointing the visual scenography, multi-channel audio from the small speakers (synthesized directly from the microcontrollers) as well as from four channels in the larger environment shifts between electronic textures. Across the architectural cable structure, the network of tiny speakers produce the behaviors of mass sonic structures made up of many small elements (sonic grains) creating swarms of tiny sounds that resemble a field of cicadas or masses of insects – akin to Xenakis' interest in the stochastic movement of mass structures.

[55] See Salter 2012.

[56] Originally created by Sofian Audry, *Qualia* has been used in numerous agent-based artworks. Project source URL: https://github.com/sofian/qualia.

In order to explore how such a system of many light and sound nodes could self-organize and respond to its environment, we used an open source C++ library that would allow us to design a series of agent-based systems. The library, named *Qualia*[56], is based on a metaphor taken from control theory and cybernetics: that of an artificial agent acting inside an environment, which in turn gets modified by these actions and gives the agent feedback in the form of an observation. Observations are usually incomplete and local to the agent. An interesting characteristic of such a setup is that each agent has its own environment or, one could say, its own world that both changes the agent (through observations) and is changed by it (through actions).

One of the main advantages of *Qualia* is that the software components are interchangeable. Thus, for a given environment, we can swap the agent (thus changing the behavior) or, for the same agent, swap the environment (for example, train an agent in a simulation environment and then run it in the real world). This agent-environment control loop is embodied in the code itself, constraining us to think in a certain way and to create within a certain set of boundaries. These constraints have strong repercussions for both the creation process and the observable behaviors in the final work itself.

As part of *N-Polytope*, we created four different agent-environment couplings or processes: *Drunk*, *Fireflies*, *Boosters* and *Chasers*. Two of these algorithms (*Boosters* and *Chasers*) use procedures from *reinforcement learning*, a branch of machine learning that aims to address the problem of an agent adapting to its environment. We view these processes as compositional techniques – procedures that generate behaviors unfolding in time, which we shape by means of a set of initial conditions, and then by mapping them into the environment in perceptually observable form, i.e., in terms of light, sound and spatial position of events located on the physical structure.

Random walks as simple Markov chains

The first algorithm implemented, *Drunk*, consists of a global-level agent that outputs, as its actions, brightness intensities for all of the

144 LEDs using a hierarchical, one-dimensional random walk procedure. Random walks are the epitome of dynamic markovian stochastic processes,[57] mathematical techniques used by Xenakis in many of his works, such as the instrumental composition *N'Shirna* (1975).[58] They represent a simple process whereby a variable changes its value by taking small, random steps, resulting in a staggering motion (hence the name "drunk").

[57] In Markovian stochastic processes, the probability of future states depend only of the current state and not on the sequence of states the process went through in the past. Such processes are thus often said to be memoryless.

[58] See Xenakis 1992, 246-247; 289.

We applied this procedure in *n-Polytope* in order to make a random walk in the 144-dimensional space of light intensities, resulting in the brightness of all of the LEDs changing randomly and independently in a staggered motion. However, we can create more variations by grouping LEDs in different ways and performing a random walk for each group. In implementing the *Drunk* process, we thus created three different kinds of groups: 48 node groups (each controlling their 3 LEDs), 12 line/cable groups (each controlling 12 LEDs) and one top-level group (controlling all 144 LEDs at once). These groups were mixed using four parameters (one for the individual LEDs, one for the nodes, one for the cables and one for the global-level), allowing us to have fine-grained control over the light environment generated by the procedure.

For example, by setting the parameter controlling the top-level to 100% and the others to 0%, all the LEDs will have the exact same intensity which staggers in unison as a single light entity. If we set both the cable-level and the LED-level parameters to 50% and the others at 0%, we will see each line of LEDs staggering approximately at the same pace, with small variation for each individual light. By setting all parameters to 25%, we get a mix of the four levels of control.

We can think of this procedure as a hierarchical set of nested agents, with the top-level agent setting the general motion while the sub-level agents refine this motion down to the individual LED's level. As an algorithmic procedure, *Drunk* is clearly the closest to Xenakis' own work with stochastics. What is interesting to us here is the fact that random walks can be seen both as a statistical generative process of the kind Xenakis had in mind, but also as exhibiting the motion of an autonomous agent (albeit a very primitive one).[59]

[59] Xenakis argues in favor of using Markovian processes on different scales in Xenakis, 1981, 19.

Emergent synchronizations of light and sound

The second algorithm, *Fireflies*, is rather different in nature. While the *Drunk* procedure is a closed system with neither inputs nor influence from its environment, the firefly agent model can send and receive from its environment simple signals in the form of either light or sound. As opposed to the mathematical abstractness of group theory which Xenakis used to control the organization of groups of flashing lights in the *Polytope de Montréal*, we instead resorted to exploring the manner in which agents could self-organize their behaviors based on continuous input from their environment. These agents thus can produce potentially emergent patterns that could not only be humanly perceived in terms of their spatial position and distribution but also in terms of the temporal actions by way of synchronized pulses and other types of rhythmic behaviors.

Fireflies is based on a procedure designed to synchronize ad-hoc wireless networks and inspired by the behavior of fireflies in South-East Asia. [60] In our implementation, each node of the *n-Polytope* installation is a "firefly" agent that "flashes" the LEDs it controls at a specific time interval. When the procedure is launched, the agents are desynchronized: sparkles of light are emitted all across the topology of the cabled structure in seemingly unrelated, random patterns. However, each time an agent perceives a flash of light coming from one of its neighbors with its photocell, it offsets its internal clock by a small fraction, making it more likely to flash. In other words, when the agent sees another flash, it adjusts itself to try and better match the flashing of its neighbors in the future. As a result, as time passes, interaction between the agents begins to emerge. At times, some agents seem to initiate a chain reaction where their flashing triggers flashing of their immediate neighbors, which in turn activates their neighbors, generating cascades of light bursting in massive ripples. Two, sometimes three such networks form, linked through space but separated in time. As they tend to refine their synchrony, suddenly, there is a long, dark silence. The room is filled with emptiness and time is frozen until, in a spectacular tempest of cold, white light, all the agents start flashing at the same time.

[60] Tyrrell, Alexander, Gunther Auer, and Christian Bettstetter (2006) "Fireflies As Role Models for Synchronization in Ad Hoc Networks." In *Proceedings of the 1st International Conference on Bio Inspired Models of Network, Information and Computing Systems*. BIONETICS '06. New York, NY, USA: ACM.

Fireflies works with either light or sound. At the beginning of the installation's 12-16 minute compositional cycle, we begin with sound, synthesized directly from the 48 microcontroller nodes and output through the small speakers with similar results. In the case of audio, the synchronization is less perceptually discernable because the agents' sounds are mixed within the global background soundscape. However, the propagation effect of sounds responding to one another creates a strong immersive impression where one feels like they are walking in a field of cicadas or in a frogs' pond.

The process unfolds from a chaotic, distributed, microscale behavior to a disciplined, singular, monumental one. In contrast to the closed nature of the *Drunk* algorithm, here agents have inputs (photocell/microphone) and outputs (LEDs/speakers) which are related through a feedback loop that pushes them to act the same way; to become a singular entity. Thus, one could say that as the system becomes increasingly ordered, it also becomes more monolithic. What is interesting from an aesthetic point of view is clearly not the purpose of the agents (which is to attain this perfect synchrony) but rather the process of going from discord to unison, which happen through the emergence of different ephemeral temporal patterns.

Connectionist agents that learn their world

The last two algorithms make use of a reinforcement learning algorithm (RL), a branch of machine learning that aims to address the problem of how agents can or should best adapt to their environment. The field of RL emerged in the late 1980s as the result of a coalescence between behavioral psychology, optimal control theory and dynamic programming.[61]

In reinforcement learning, agents evolve inside an environment following a discrete time-based stochastic control procedure known as a Markov decision process (MDP).[62] In such a procedure, an agent takes actions in the environment based on what it observes. Each action modifies the environment, yielding a new set of observations for the agent as well as a single-valued reward feedback. The goal of the agent is to maximize its rewards over time. In order to do so, it usually proceeds by trial-and-error, trying to infer what is the best course of action to take in a given context based on the rewards and punishments it has received in the past.

[61] Sutton, Richard S., and Andrew G. Barto (1998) *Reinforcement learning: An introduction*. Cambridge, MA: MIT Press, 16.

[62] Ibid.

In *n-Polytope*, we employ a reinforcement learning algorithm known as Q-Learning, in which the agent bases its decisions on an estimator called a Q-function. This function involves two parameters (the observation *s* and an action *a*)[63] and produces an estimate of the expected reward the agent will get for taking action *a* in context *s*:

[63] In reinforcement learning, observations are often called "state", hence the variable *s* which is used in the literature. However, we prefer to use the term observation because it really refers to what is perceived by the agent rather than its actual state (which can be partly hidden to it).

Q(s,a) = estimated expected reward for taking action *a* given observations *s*

After each action taken, the Q(s,a) function is slightly adapted by the agent to give a better approximation of the expected reward in the future. In other words, it adjusts itself based on an error-correcting negative feedback mechanism.

There are a certain number of ways the agent can use this information to choose the actual action it is going to take. The way the agent uses the Q-function to choose its actions is called a control *policy*. The most obvious policy is just to take the action with the maximum Q-value, i.e.:

a = argmaxa' Q(s,a')

This is what we call a *greedy* policy, however, the Q(s, a) function is learned and thus, it is not the actual expected reward but rather an *approximation* of it based on what the agent has been observing in the past (i.e., in the state-action pairs it went through and the rewards it received in return). A purely greedy policy favors *exploitation* of what the agent already knows, which is done at the expense of *exploration*. Concretely, greedy agents will tend to get stuck in the same, safe zone where they started which is at best a local maximum, because their strategy has kept them from trying out different things, such as wandering inside the whole state-action environment.

As such actions more often than not result in wholly sub-optimal behaviors,[64] we have to introduce some exploration in the policy to alleviate this problem. A simple way to do this is to allow the agent to be greedy most of the time but, once in a while (say, with a probability ε) letting it take a random action. This variation on the greedy policy is called the ε-greedy policy and is the one most often used in reinforcement learning due both to the simplicity of its implementation and to its surprising efficiency in allowing the agent to converge to a good solution in most situations.

[64] An optimal behavior would be one yielded by a Q-function which maximizes the reward of the agent.

Within the context set out earlier however, the concepts of exploration and exploitation resemble those of order and disorder. Controlling the ε parameter, which, in essence, determines how explorative/disordered the agent is, can be used in real time to enable the *n-Polytope* agents and hence, their environment to move between total chaos (random agent) and total order (greedy agent). While this move is operational in a mathematical sense, whether or not such an order or disorder continuum is actually perceivable is a question we will leave for the conclusion.

The Q-function can take many forms, from simple value-tables to decision trees and genetic algorithms. In the case of *n-Polytope*, we chose to use a well-known connectionist[65] model known as a feedforward artificial neural network (ANN) as our Q-function.[66] One of the most widespread machine learning techniques, the ANN is a simplified mathematical model of actual neural networks in the human brain.

[65] Connectionism refers to a multidisciplinary approach that believes intelligence and cognition are best modeled as the emergent organization of interconnected independent units.

[66] Christopher M. Bishop (1995) *Neural Networks for Pattern Recognition*. Oxford: Oxford University Press.

ANNs follow a historical-technical path that dates back to early cybernetics, embodied in the neural model of propositional logic proposed by Warren McCulloch and Walter Pitts which later inspired the first adaptive, linear connectionist devices such as Frank Rosenblatt's Perceptron (Rosenblatt, 1957) in the late 1950s. The perceptron is a simplified model of a human neural network in the shape of a thresholded linear function that is able to classify a pattern in one of two categories. It maps a set of typically binary inputs (input neurons) to a binary output (output neuron) using a layer of parametric values called *weights* (representing the synapses). The weights are usually initialized randomly. A simple training procedure allows the perceptron to adjust its weights based on a series of example inputs for which the expected output is known.

For example, suppose that we want to differentiate between handwritten letters that are either A or B. We create a database of 8x8 black and white images of handwritten A's and B's. We then have the perceptron process each of these images, computing the average error of the system. When every example has been processed, we then slightly update the weights according to their contribution to the error, trying to diminish the system's error on its next run. We repeat the procedure for several steps, until the average error of the perceptron converges to a minimum. The adaptive procedure is a definite example of the kind of negative feedback Wiener had in mind, where a system constantly adjust its internal parameters based on the error of its own outputs.

The excitement from the scientific community about these models would end abruptly with the publication of Minksy and Papert's infamous critique of perceptrons (Minsky and Papert, 1969). By showing that even simple problems are unsolvable by a linear neural network such as a perceptron, Minsky and Papert's argument put a halt to the non-symbolic, distributed approach advanced with the Perceptron model. The main limitation of perceptrons they highlighted was that, being linear models, they were unable to represent non-linear data distributions, which is the norm rather than the exception. The following decade would push what was then called "connectionism" into the background in favor of symbolic and heuristic approaches; a period which would later be known as the "AI winter."

In the mid-80s, a major breakthrough would suddenly bring connectionism back on the scene as David E. Rumelhart, Geoffrey E. Hinton and Ronald J. Williams proposed an algorithm to train a multi-layer perceptron (MLP) (Rumelhart et al., 1986) which would later be known simply as artificial neural network (ANN). As its name indicates, the MLP consists of several perceptrons stacked on top of each other in interconnected layers of neurons. As each layer projects the previous layer's outputs using a non-linear threshold, however, it circumvents the main caveat of perceptrons: their inability to separate non-linear data.

ANNs can be used for classification as well as for regression, i.e., function approximation. The main difference with the earlier perceptrons is that ANNs not only have an input and an output layer of neurons but also a *hidden* layer between the inputs and outputs.[67] Like in the perceptron, a first set of weights maps the input neurons to the hidden layer, where intermediate higher-level representations of the inputs are created. One way to understand this procedure is to consider each hidden neuron as the output neuron of a perceptron. The difference is that in the case of the perceptron, the output is transformed into a binary value using a hard threshold. In an ANN, the hidden neurons are transformed using a smooth, non-linear thresholding function that pushes them towards a binary value. Finally, the hidden neurons linearly combine using a second set of weights to produce the output neuron value.[68]

[67] Bengio, 2009: Bengio, Yoshua (2009) "Learning Deep Architectures for AI." *Foundations and Trends in Machine Learning* 2 (1): 1–127. http://sensestage.hexagram.ca/

[68] One can look at an ANN as a network of agents, where each hidden neuron is seen as a minimal agent that becomes an expert classifier over a specific domain. These agents are encouraged to divide the input space between them. They are then combined to produce the final output, as if they were "voting".

Like real neural networks in the brain, ANNs represent information in a *distributed* way, as opposed to a symbolic, local representation. At the beginning of the procedure, the weights are initialized randomly, such that the network decisions are completely chaotic (i.e., the entropy is maximal). By getting exposed to the environment (in other words, by being subjected to examples sampled from the real world distribution), taking actions in a range of different contexts, the network is slowly adjusted to make better predictions. In the case of Q-Learning, for instance, this means giving a better estimate of the expected return. Thus, the network itself becomes increasingly ordered as its parameters (weights) are shaped to decrease the global entropy of the model. Another way to put it is that by acting in its environment, the agent gathers information about that environment and how it can influence it, which allows it to better act out in the future.

Although using RL techniques, the third algorithm, *Boosters*, works in a similar fashion as *Fireflies*: there is one agent for each light and sound node, each of which can emit flashes of light as well as perceive the brightness of its neighbors. The *Boosters* agents accumulate energy in a virtual "battery" while they are at rest and when their neighbors emit light. At each step, the agents can choose to either stay at rest or emit a burst of light. If they choose the latter, the accumulated energy produces a burst with a light intensity proportional to the energy spent.

The *Boosters* agents receive a reward for producing a flash, and this reward is even larger when the flash is more intense. Their best strategy is thus to wait until their battery is full before taking a flash action. Since there is a "blind" relaxation period after emitting a burst, during which the light perceived from the environment does not add to the energy, the agents' best strategy as a group is also to intersperse their flashing. Visually, the perceptual impression that results is thus one of a mass of individual lights pulsating over a range of different intensities, only to occasionally burst and blank out for a moment in order to return to their struggle again.

The last process called *Chasers* creates a simulation where agents move across each of twelve lines, a mapping in which each line corresponds to one of the physical steel cables in the installation. Instead of working with analog / continuous properties like light intensity and amplitude of sound, we employ a simple discrete representation of the agents' position in space. Each cable represents a one-dimensional "world" with 12 discrete locations/cells. As common in cellular automata type of systems, the world "wraps-around" the edges, meaning that the first cell of each line is defined as adjacent to the last one. At any specific moment in time, an agent occupies one and only one of the twelve cells and can choose to either stay in place or move to one of the adjacent cells. The only information (observation) the agent receives is the distance (in number of cells) between itself and the next agent, in both directions. The agents' positions are represented by an illumination of the corresponding LED on the cable where "stacked" agents result in a brighter emission of light.

The reward function is a composition of different parameters:

- The reward on touch (rt) rewards the agent (or punishes it) for being on the same spot as another agent.
- The reward on move (rm) rewards the agent for moving in a given direction (and punishes it for going the opposite way).
- The reward on stay (rs) rewards the agent for staying put (and punishes it for moving).

These parameters can be used independently (by keeping the other ones to zero) or they can be combined to foster different behaviors in agents, as demonstrated in the following table:

Touch (rt)	Move (rm)	Stay (rs)	Resulting behavior
1	0	0	Try to catch other agents at all cost.
-1	0	1	Try to evade other agents and otherwise stay still.
0	1	0	Move left-to-right no matter what.
2	-1	0	Try to catch other agents first and foremost, but with a preference for moving right-to-left.
-1	0	-1	Always move but avoid collisions.

Furthermore, we achieve more variation by combining agents with different reward functions on the same cable, thus generating different kinds of movements such as predator-prey "chases" and other adaptive dances. In the installation, we start by adding a few agents and then grow, increasing the number until the impression of total disorderarises. In this sense, the shift in the behavior of the agents gradually results in a growing sense of disorder, achieved by sudden discontinuities in the rhythm of their movement up and down the lines and thus, making it increasingly difficult for observers to recognize their patterns.

Conclusion: Research-Creation towards the Edge of Chaos

In this chapter, we have traced conceptual, historical, aesthetic and techno-scientific arcs in both Xenakis' work with probabilistic systems within the framework of his Polytope installations as well as in our own re-imagining of the Polytopes for our current historical and techno-scientific moment. But a critical question remains, namely, what are the stakes in choosing the techniques we do? What worlds do they produce, how do they function and why should we care?

By choosing a certain technique, in this case, the modeling of an open system whose boundaries are permeable with its environment, we set up a different ontology: another way of making the world that Pickering in his work on the British cyberneticians referred to as "non-modern."[69] For Pickering, this non-modern ontology has two key characteristics. The first is a refusal to accept a dualist vision of the world - splits between mind and matter or "the reciprocal coupling of people and things." But we go further than Pickering for the entanglement that occurs in *n-Polytope* is one not only of things and people on the same plane but one of necessary co-production. For example, in a system that swings between order and disorder, the determination of these characteristics is based on two different levels: (1) the intrinsic orderedness of the system itself due to its actions and behavior and, (2) the manner in which a perceiving entity interprets the spatio-temporal behavior of that order or disorder. Here, the role of the observer is critical because the observer and the system are, in effect, co-producing each other. In other words, cybernetics as a science not only posited feedback and control networks involving machines but also networks of brains and bodies. In this sense,

[69] Andrew Pickering (2010) *The Cybernetic Brain: Sketches of Another Future.* Chicago: University of Chicago Press, 17-18.

observers are living cognitive systems who aim to extract and interpret information from the environment and hence, try to find order within it.

The second aspect of Pickering's non-modern ontology is its "futurity"; its openness to the future. "[...] cybernetics stages for us a vision not of a world characterized by graspable causes, but rather of one in which reality is always "in the making"...[70] Cybernetics functions as an evolutionary science and practice since the ability of a system to be open to its environment and regulate itself according to this environment suggests its plasticity and adaptability. Embodying what Pickering labels "temporally emergent", Xenakis' use of stochastics is a blow not only to serial techniques in music but also to the positioning of any phenomena in a temporally predictable manner.

[70] Ibid 19.

If, according to Pickering, Xenakis' choice of techniques and the choices we made in *n-Polytope* sets up an "ontology that makes a difference" in the type of world that results, a perhaps more important question concerns the process of negotiation between how such formalized processes derived from mathematical and scientific contexts inform and enable artistic choices and resulting aesthetic experiences. Of course, by now it is evident that Xenakis is not only recognized for musical and architectural contributions but also for his contributions to enlarge and extend the discourse between art and science from a *research-creation* point of view.[71]

In a 1981 seminar at IRCAM, for example, Xenakis argued for a new relationship between art and science in which art would "pose problems that mathematics should solve" with the creation of new theories. The future "artist-originator" should thus be a generalist, trained in various scientific fields ranging from mathematics to genetics, humanities and history, so that s/he acquires a kind of "universality" based on forms, architecture and morphology.[72] But Xenakis does not propose a simple marriage between art and science. Art and science are *alloys*-an admixture that forms an impure substance whose properties as a whole will be different than each of its individual constituents. The form that results is wholly something new, not simply one thing (scientific ideas) applied onto another thing (artistic intention).

[71] In contrast to concepts such as "practice-based research" and "art research," the Canadian context has set an international example with its notion of "research-creation." Here, the term signifies that artistic processes under the heading of "research" must ask clear questions, offer theoretical contextualization within the relevant field or fields of literary/artistic inquiry, present a well-considered methodological approach, as well as meet peer standards of excellence for publication, public performance or exhibition.

[72] Xenakis, 1981.

It is in this sense of the generation of something new that Xenakis proposes the application of techniques from science in order to generate not only new *knowledge* (the primary aim of research) but new artistic forms or morphologies (the aim of art). The application of mathematical procedures is neither for efficiency's sake nor for problem solving but rather the enabling of new artistic forms of thought; a "general morphology."[73] New artistic questions can only originate from the materialization, the realization of new forms. It is precisely the issues of order and disorder, of science and art, that remain and live on in Xenakis' own practices and that enable and inform our own worldmaking.

[73] Xenakis 1981, 64-66.

MACHINIC

Machinic Heterogenesis

Félix Guattari, "Machinic Heterogenesis," translated by James Creech, in Verena Andermatt Conley, et al. eds., Rethinking Technologies (Minneapolis: University of Minnesota Press, 1993), pp. 13-28.

Félix Guattari

Machinism

Although machines are usually treated as a subheading of "technics," I have long thought that it was the problematic of technics that remained dependent on the questions posed by machines. "Machinism" is an object of fascination, sometimes of delirium. There exists a whole historical "bestiary" of things relating to machines. The relation between human and machine has been a source of reflection since the beginning of philosophy. Aristotle considers that the goal of *techné* is to create what nature finds it impossible to achieve so that *techné* sets itself up between nature and humanity as a creative mediation. But the status of this "intercession" is a source of ambiguity. While mechanistic conceptions of the machine rob it of anything that can differentiate it from a simple construction *partes extra partes*, vitalist conceptions assimilate it to living beings, unless the living beings are assimilated to the machine. This was the path taken by Norbert Wiener as he opened up the cybernetic perspective in *Cybernetics*.[1] On the other hand, more recent systemist conceptions reserve the category of autopoiesis (or self-production) for living machines (in Francisco Varela's *Autonomie et connaissance*),[2] whereas an older Heideggerian mode of philosophy entrusts *techné*, in its opposition to modern technicity, with the mission of "unveiling the truth," thus setting it solidly on an ontological pedestal - on a *Grund* - that compromises its definition as a process of opening. It is by navigating between these two obstacles that we will attempt to discern the thresholds of ontological intensity that will allow us to grasp "machinism" [*le machinisme*] all of a piece in its various forms, be they technical, social, semiotic, or axiological. With respect to each type of machine, the question will be raised not of its vital autonomy according to an animal model, but of its specific enunciative consistency.

The first type of machine that comes to mind is that of material assemblages [*dispositifs*], put together artificially by the human hand and by the intermediary of other machines, according to diagrammatic schemas whose end is the production of effects, of products, or of particular services. From the outset, through this artificial montage and its teleology [*finalisation*] it becomes necessary to go beyond the delimitation of machines in the strict sense to include the functional ensemble that associates them with humankind through multiple components:

[1] Norbert Wiener, *Cybernetics; or, Control and Communication in the Animal and the Machine* (Cambridge, MA: Massachusetts Institute of Technology Press, 1948).

[2] Francisco Varela, *Autonomie et connaissance* (Paris: Seuil, 1989).

Material and energy components;
Semiotic components that are diagrammatic and algorithmic;
Social components relative to the search, the formation, the organization of work, the ergonomics, the circulation, and the distribution of goods and services produced;
The organ, nerve impulse, and humoral components of the human body;
Individual and collective information and mental representation;
Investments by "desiring machines" producing a subjectivity in adjacency with its components; and
Abstract machines setting themselves up transversally to the machinic, cognitive, affective, and social levels considered above.

In the context of such a functional ensemble, which henceforth will be qualified as *machinic ordering* [*agencement machinique*], the utensils, the instruments, the simplest tools, and, as we shall see, the slightest structured parts of a machinery will acquire the status of a protomachine. Let us deconstruct, for example, a hammer by removing its handle. It remains a hammer but in a "mutilated" state. The "head" of the hammer, another zoomorphic metaphor, can be reduced by fusion. It will then cross the threshold of formal consistency, causing it to lose its form, its machinic gestalt, which works on a technological as well as on an imaginary level (as, for example, when we evoke the obsolete memory of the hammer and sickle). From then on, we are confronted with nothing more than a metallic mass that has been returned to its smooth state – to deterritorialization – preceding its entrance into that mechanical form. But we will not settle for this experiment, similar to Descartes's experiment with a piece of wax. In effect, we can move in the opposite direction of this deconstruction and its limit threshold, toward the association of the hammer and the arm, the nail, the anvil, which maintain among each other relationships that we can call syntagmatic. Their collective dance even expands to include the defunct corporation of blacksmiths, the sinister epoch of the old iron mines, ancestral use of iron-rimmed wheels. As Leroi-Gourhan pointed out, the technological object is nothing outside of the technological ensemble to which it belongs. But is it any different with sophisticated machines such as robots, which we suspect – probably with good reason – will soon be engendered exclusively by other robots in a gestation involving virtually no human action until some glitch requires our residual, direct intervention? But doesn't all that sound like a kind of dated science fiction? In order to acquire more and more life, machines require more and more abstract human vitality as they make their way along their evolutive phyla. Thus, conception by computer – expert systems and artificial intelligence – gives us back at least as much as it takes away from thought, because in the final analysis it only subtracts inertial schemas. Computer-assisted forms of thought are thus mutant and arise from other kinds of music, from other universes of reference.

It is thus impossible to refuse human thought its part in the essence of machinism. But how long can we continue to characterize the thought put to work here as human? Doesn't technicoscientific thought emerge from a certain type of mental and semiotic machinism? Here it becomes necessary to establish a distinction between, on the one hand, semiologies producing significations that are the common currency of social groups and, on the other, asignifying semiotics that, despite the significations they can foster, manipulate figures of expression that work as diagrammatic machines in direct contact with technical-experimental configurations. Semiologies of signification play on distinctive oppositions of a phonemic or scriptural order that transcribe enunciations [*énoncés*] into expressive materials that signify. The structuralists liked to make the Signifier a unifying category for all expressive economies of whatever order, be it language, icon, gesture, urbanism, or cinema. They postulated a general translatability able to signify all forms of discursivity. But in doing that, did they not miss the mark of a machinistic autopoiesis that does not derive from repetition or from mimesis of significations and their figures of expression, but that is linked instead to the emergence of meaning and of effects that are no less singular for being indefinitely reproducible?

Ontological Reconversions

This autopoeitic nexus of the machine is what wrests it from structure. Structural retroactions, their input and output, are called upon to function according to a principle of eternal return; they are inhabited by a desire for eternity. The machine, on the contrary, is haunted by a desire for abolition. Its emergence is accompanied by breakdown, by catastrophe, by the threat of death. Later on we will have to examine the different relations of alterity thus developed, relations that constitute differences from structure and its homeomorphic principle. The principle of difference proper to machinistic autopoiesis is based on disequilibrium, on prospecting for virtual universes far from equilibrium. And it is not just a question of a formal rupture of equilibrium, but a radical ontological reconversion. And that is what definitively denies any far-reaching importance to the concept of Signifier. The various mutations of ontological referent that shunt us from the universe of molecular chemistry to the universe of biological chemistry, or from the world of acoustics to the world of polyphonic and harmonic music, are not brought about by the same signifying entities. Of course, lines of signifying decipherability, composed as they are of discrete figures subject to being converted into binary oppositions, syntagmatic and paradigmatic chains, can be linked from one universe to another so as to give the illusion that all phenomenological regions are woven together in the same fabric. But things change completely when we turn to the texture of these universes of reference, which are, each time, singularized by a specific constellation of expressive intensities, given through a pathic relationship, and delivering irreducibly heterogeneous ontological consistencies. We thus discover as many types of deterritorialization as we do characteristics of expressive matter. The signifying articulation that looms above them – in its superb indifference and neutrality – is unable to impose itself upon machine intensities as a relation of immanence. In other words, it cannot preside over what constitutes the nondiscursive and self-enunciating nexus of the machine. The diverse modalities of machine autopoiesis essentially escape from signifying mediation and refuse to submit to any general syntax describing the procedures of deterritorialization. No binary couple such as being/entity [*être/étant*], being/nothingness, being/other can claim to be the "binary digit" of ontology.

Machinic propositions escape the ordinary game of energetic/spatial/temporal discursivity. Even so, there nevertheless exists an ontological "transversality." What happens at a particle/cosmic level is not without relationship to what happens at the level of the socius or the human soul, but not according to universal harmonics of a platonic nature (as in "The Sophist"). The composition of deterritorializing intensities is incarnated in machines that are abstract and singularized, machines that have the effect of rendering things irreversible, heterogeneous, and necessary. On this score, the Lacanian signifier is doubly inadequate. It is too abstract in that it renders too easily translatable the materials of heterogeneous expressions; it falls short of ontological heterogenesis; it gratuitously renders uniform and syntactic the diverse regions of being. At the same time, it is not abstract enough because it is incapable of accounting for the specificity of these autopoietic nexes, to which we must now return.

Autopoietic Nexus

Francisco Varela characterizes a machine as "the ensemble of the interrelations of its components, independent of the components themselves."[3] The organization of a machine thus has nothing to do with its materiality. From there Varela goes on to distinguish two types of machines: allopoietic machines which produce something besides themselves, and autopoietic machines, which continually engender and specify their own organization and their own limits. They carry out an incessant process of replacing their components because they are subject to external perturbations for which they are constantly forced to compensate. In fact, Varela reserves the qualification "autopoietic" for the biological domain. Social systems, technical machines, crystalline systems, and so forth are excluded from the category. That is the sense of his distinction between allopoiesis and autopoiesis. But autopoiesis, which thus encompasses only autonomous, individuated, and unitary entities that escape relations of input and output, lacks characteristics essential to living organisms, such as being born, dying, and surviving through genetic phyla. It seems to me, however, that autopoiesis deserves to be rethought in relation to entities that are evolutive and collective, and that sustain diverse kinds of relations of alterity, rather than being implacably closed in upon

[3] Varela, *Autonomie et connaissance*; translation by James Creech.

themselves. Thus institutions, like technical machines, which, in appearance, depend on allopoiesis, become ipso facto autopoietic when they are seen in the framework of machinic orderings that they constitute along with human beings. We can thus envision autopoiesis under the heading of an ontogenesis and phylogenesis specific to a mecanosphere that superimposes itself on the biosphere.

The phylogenetic evolution of machinism can be construed, at a first level, in the fact that machines arise by "generations"; they supersede each other as they become obsolete. The filiation of past generations is continued into the future by lines of virtuality and by their implied genealogical descendancy [*arbres d'implication*]. But we are not talking about a univocal historical causality. Evolutive lineages present themselves as rhizomes; datings are not synchronic but heterochronic. For example, the industrial ascendancy of steam engines took place centuries after the Chinese empire had used them as children's toys. In fact, these evolutive rhizomes traverse technical civilizations by blocks. A technological mutation can know periods of long stagnation or regression, but it is rare for it not to resurface at a later time. That is particularly clear with technological innovations of a military nature, which frequently punctuate large-scale historical sequences that they stamp with a seal of irreversibility, wiping out empires in favor of new geopolitical configurations. But, I repeat, the same was already true of the humblest instruments, utensils, and tools that are part of the same phylogenesis. One could, for example, mount an exposition on the subject of the evolution of the hammer since the stone age, and produce conjectures about what it might become in the context of new materials and new technologies. The hammer we buy today at the hardware store is, in some ways, "appropriated" from a phylogenetic lineage with virtual possibilities for the future that are undefined.

The movement of history is singularized at the crossroads of heterogeneous machinic universes, of differing dimension, of foreign ontological texture, with radical innovations, with benchmarks of ancestral machinisms previously forgotten and then reactivated. The neolithic machine associates, among other components, the machine of spoken language, the machines of cut stone, the agrarian machines founded on the selection of seeds and a protovillage economy. The scriptural machine, on the other hand, will see its emergence only with the birth of urban megamachines (compare Lewis Mumford) correlated to the implantation of archaic empires. In a parallel fashion, great nomadic machines will be constituted from the collusion between the metallurgical machine and new war machines. As for the great capitalistic machines, their basic machinisms were proliferative: first urban, then royal state machines, commercial and banking machines, navigational machines, monotheistic religious machines, deterritorialized musical and plastic machines, scientific and technical machines, and so forth.

The question of the reproducibility of machines on an ontogenetic level is more complex. The maintenance of a machine is never fail-safe for the presumed duration of its life. Its functional identity is never absolutely guaranteed. Wear and tear, precariousness, breakdowns, and entropy, as well as normal functioning, require a certain renovation of a machine's material, energetic, and informational components, the last of which is susceptible to disappearing in "noise." At the same time, maintenance of the consistency of machinic ordering requires that the quotient of human gesture and intelligence that figures in its composition must also be renewed. Man-machine alterity is thus inextricably linked to a machine-machine alterity that plays itself out in relations of complementarity or agonistics (between war machines) or else in the relations of parts or assemblages [*pièces ou dispositifs*]. In fact, wear and tear, accident, death, and resurrection of a machine in a new "example" or model are part of its destiny and can be foregrounded as the essence of certain aesthetic machines (Cesar's "compressions," "Metamechanics," happening machines, Jean Tinguely's machines of delirium). The reproducibility of machines is thus not a pure, programmed repetition. Its rhythms of rupture and fusion, which disconnect its model from all grounding, introduce a certain quotient of difference that is as ontogenetic as it is phylogenetic.

On the occasion of these phases of transformation into diagrams, into abstract and disincarnated machines, the "soul supplement" of the machine nexus is granted its difference relative to simple material agglomerate. A pile of stones is not a machine, whereas a wall is already a static protomachine, manifesting virtual polarities, an inside and an outside, a high and a low, a right and a left. These diagrammatic virtualities lead us away from Varela's characterization of machinic autopoiesis as unitary individuation, without input or output, and prompts us to emphasize a more collective machinism, without delimited unity and whose autonomy meshes with diverse bases for alterity. The reproducibility of the technical machine, unlike that of living beings, does not rely upon perfectly circumscribed sequences of coding in a territorialized genome. Each technological machine has indeed its own plans of conception and assemblage, but, on the one hand, these are not conflated with the machine, and on the other hand, they get sent from one machine to another so as to constitute a diagrammatic rhizome that tends to cover the mecanosphere globally. The relations of technological machines among themselves, and adjustments of their respective parts, presuppose a formal serialization and a certain loss of their singularity – more so than in living machines – that is correlative to the distance assumed between the machine (manifested in the coordinates of energy/space/time) and the diagrammatic machine that develops in coordinates that are more numerous and more deterritorialized.

This deterritorializing distance and this loss of singularity must be attributed to a stronger smoothing out of the materials constitutive of the technical machine. Of course, the irregularities particular to these materials can never be completely smoothed out, but they should not interfere in the "freeplay" [*jeu*] of the machine unless required to by its diagrammatic function. Using a seemingly simple machinic ordering [*agencement machinique*], let us look closer at the couple formed by a lock and its key, at these two aspects of machinic separation and smoothing out. Two types of form, characterized by heterogeneous ontological textures, are at work here:

1. Materialized forms, which are contingent, concrete, and discrete, forms whose singularity is closed on itself, incarnated in profile F(L) of the lock and profile F(K) of the key. F(L) and F(K) never coincide completely. They evolve in the course of time as a result of wear and oxidation. But both are obliged to remain within the framework of a delimiting standard deviation beyond which the key would no longer be operational.

2. Diagrammatic, "formal" forms, subsumed by this standard deviation, which are presented as a continuum including the whole gamut of profiles F(K) and F(L) compatible with the effective unlatching of the lock.

We notice right away that the effect, the possible act of opening the lock, is located altogether in the second (diagrammatic) type of form. Although they are graduated according to the most restricted possible standard deviation, these diagrammatic forms appear in infinite number. In fact, we are dealing with an integal of forms F(K) and F(L).

This integral, "infinitary" form doubles and smooths out the contingent forms F(K) and F(L), which have machinic value only to the extent that they belong to it. A bridge is thus established "over" the authorized concrete forms. This is the operation that I am qualifying as deterritorialized smoothing out, an operation that has just as much bearing upon the normalization of constitutive materials of the machine as it does upon their "digital" and functional qualification. An iron mineral that had not been sufficiently laminated and deterritorialized would show unevenness from pounding that would falsify the ideal profiles of the key and the lock. The smoothing out of the material must remove the aspects of its excessive singularity and ensure that it behaves in a way that will take the molding of formal imprints exterior to it. We should add that this molding, in this sense comparable to photography, must not be too evanescent, and must keep a consistency that is its own and that is sufficient. There again we encounter a phenomenon of standard deviation, bringing into play both a material consistency and a theoretical diagrammatic consistency. A key made of lead or of gold might bend in a steel lock. A key brought to a liquid state or to a gaseous state immediately loses its pragmatic efficiency and falls outside the category of technical machine.

This phenomenon of formal threshold will recur at every level of intra- and extramachinic relations, particularly with the existence of spare parts. The components of technical machines are thus like the coins of a formal money, a similarity that has become even more manifest because computers have been used both to conceive and to execute such machines.

These machinic forms, this smoothing out of material, of standard deviation between the parts and of functional adjustments would tend to make us think that form takes precedence over consistency and material singularity, since the reproducibility of technological machines seems to require that each of its elements be inserted into a preestablished definition of a diagrammatic sort. Charles Sanders Peirce, who characterized the diagram as an "icon of relation" and attributed to it the algorithmic function, suggested an expanded vision that is still adaptable to the present perspective. Peirce's diagram is in effect conceptualized as an autopoietic machine, thus not only granting it a functional consistency and a material consistency, but also requiring it to deploy its various registers of alterity that remove what I call the machinic nexus from a closed identity based on simple structural relations. The subjectivity of the machine is set up in universes of virtuality that everywhere exceed its existential territoriality. Thus do we refuse to postulate a subjectivity intrinsic to diagrammatic semiotization, for example, a subjectivity "nestled" in signifying chains according to the famous Lacanian principle: "A signifier represents the subject for another signifier." There does not exist, for the various machine registers, a univocal subjectivity based on rupture, lack, and suture, but rather, ontologically heterogeneous modes of subjectivity, constellations of incorporeal universes of reference that take a position of a partial enunciator in domains of multiple alterity that it would be better to call domains of "alterification." We have already encountered certain of these registers of alterity:

The alterity of proximity among different machines and among parts of the same machine;

The alterity of internal material consistency;

The alterity of formal diagrammatic consistency;

The alterity of evolutive phyla; and

The agonistic alterity among war machines, which we could expand to include the "autoagonistic" alterity of desiring machines that tend to their own collapse, their own abolition, and, in a more general way, the alterity of a machinic finitude.

Another form of alterity has been taken up only very indirectly, one we could call the alterity of scale, or fractal alterity, which sets up a play of systematic correspondence among machines belonging to different levels.[4]

Even so, we are not establishing a universal table of forms of mechanical alterity because their ontological modalities are infinite. Such forms

[4] Leibniz, in his concern to homogenize the infinitely large, and the infinitely small, thinks that the living machine, which he assimilates to a divine machine, continues to be a machine even in its smallest parts. This would not be the case for a machine made by human art. See, for example, Gilles Deleuze, *Le Pli* (Paris: Minuit, 1988); translated by Tom Conley as *The Fold* (Minneapolis: University of Minnesota Press, 1993).

are organized by constellations of reference universes that are incorporeal and whose combinatories and creativity are unlimited.

Archaic societies are better armed than white, male, capitalistic subjectivities to map this multivalence of alterity. In this regard I would refer the reader to the exposé by Marc Augé showing the heterogeneous registers to which the Legba fetish in the African Fon society refers. The Legba is set up transversally in:

A dimension of destiny;

A universe of life principle;

An ancestral filiation;

A materialized good;

A sign of appropriation;

An entity of individuation; and

A fetish at the entrance to the village, another on the door of the house, and then at the entrance to the bedroom after initiation, and so forth.

The Legba is a handful of sand, a receptacle but at the same time the expression of the relation to others. It is found at the door, at the market, on the village square, at the crossroads. It can transmit messages, questions, answers. It is also the instrument of relation to the dead or to ancestors. It is at the same time an individual and a class of individuals, a proper name and a common name. "Its existence corresponds to the evidence of the fact that the social is not only a matter of relation, but a matter of being." Augé underscores the impossible transparency and translatability of symbolic systems. "The Legba apparatus ... is constructed according to two axes. One seen from the outside on the inside, the other from identity to alterity."[5] Thus, being, identity, and relationship to the other are constructed, through fetishist practice, not only as symbolic, but also as ontologically open.

[5] Marc Augé, "Le Fétiche et son objet," in *L'Objet en psychanalyse*, ed. Maud Mannoni (Paris: Denoël, 1986).

Contemporary machinic orderings, even more than the subjectivity of archaic societies, lack a univocal standard referent. But we are much less used to irreducible heterogeneity– or "heterogenicity"– of their referential components. Capital, Energy, Information, the Signifier are so many categories that make us believe in the ontological homogeneity of referents – biological, ethnological, economic, phonological, scriptural, or musical referents, to mention only a few.

In the context of a reductionist modernity, it is up to us to rediscover that a specific constellation of reference universes corresponds to each emergence of a machinic crossroads, and that from that constellation a nonhuman enunciation is instituted. Biological machines advance the universes of the living, which differentiate themselves into vegetal becomings and animal becomings. Musical machines are founded on the basis of sonoric universes that have constantly been reworked since the great polyphonic mutation. Technical machines are founded at the crossroads of the most complex and the most heterogeneous enunciative components. Heidegger, who well understood that it was not only a means, came to consider technics as a mode of unveiling of the domain of truth. He took the example of a commercial airplane waiting on a runway: the visible object hides "what it is and the way in which it is." It does not unveil its "grounds" except "insofar that it is commissioned to assure the possibility of a transportation," and, to that end, "it must be commissionable, that is, ready to take off, and it must be so in all its construction."[6] This interpellation, this "commission," that reveals the real as a "ground" is essentially operated by man and is translated in terms of universal operation, travel, flying. But does this "ground" of the machine really reside in an "already there," in the guise of eternal truths, revealed to the being of man? Machines speak to machines before speaking to man, and the ontological domains that they reveal and secrete are, at each occurrence, singular and precarious.

[6] Martin Heidegger, *Essais et conférences* (Paris: Gallimard, 1988), 1, pp. 9, 48.

Let us return to this example of a commercial airplane, no longer in a generic sense, but through the technologically dated model that was christened the Concorde. The ontological consistency of this object is essentially composite; it is at the crossroads, at the pathic point of constellation and agglomeration of universes, each of which has its own ontological consistency, marks of intensity, particular organization and coordination: its specific machines. The Concorde arises at the same time:

From a diagrammatic universe, with its theoretical "feasibility" plans;

From technological universes that transpose this "feasibility" in terms of materials;

From an industrial universe capable of producing it effectively;

From a collective, imaginary universe corresponding to a desire sufficient to bring the project to term; and

From political and economic universes allowing, among other things, the earmarking of funds for its production.

But the ensemble of these final, material, formal, and efficient causes, in the final analysis, don't make the grade! The object Concorde travels between Paris and New York, but it has remained bolted to the economic ground. This lack of economic consistency has definitively imperiled its global ontological consistency. The Concorde exists only within the limits of a reproducibility of twelve copies and at the root of the possibilist phylum of supersonics yet to come. That is already no small feat!

Why am I insisting so much on the impossibility of establishing solid grounds for a general translatability of various components of reference and for the partial enunciation of ordering? Why this lack of reverence toward the Lacanian conception of the signifier? It is precisely because this theorization, coming out of linguistic structuralism, does not get us out of structure, and prohibits us from entering the real world of the machine. The structuralist signifier is always synonymous with linear discursivity. From one symbol to another, the subjective effect emerges with no other ontological guarantee. As against that, heterogeneous machines, such as those envisioned in our schizoanalytic perspective, yield no standard being orchestrated by a universal temporalization. In order to illuminate this point I must establish distinctions among the different forms of semiological, semiotic, and encoding linearity:

1. encodings of the "natural" world, which operate in several spatial dimensions (those of crystallography, for example), and which do not imply extraction of autonomized encoding operators;

2. the relative linearity of biological encodings, for example, the double helix of DNA, which, based on four basic chemicals, develops equally in three dimensions;

3. the linearity of presignifying semiologies, which is developed in relatively autonomous parallel lines, even if phonological lines of spoken language always seem to overcode all the others;

4. the semiological linearity of the scriptural signifier, which imposes itself in a despotic manner upon all other modes of semiotization, which expropriates them and even tends to make them disappear in the framework of a communicational economy dominated by data processing (or, to be more precise, data processing at its current state of development, as this state of affairs is in no way definitive!); and

5. the superlinearity of asignifying substances of expression, where the signifier sheds its despotism, where informational lines can retrieve a certain parallelism and work in direct contact with referent universes that are in no way linear and that tend, moreover, to escape any logic of spatialized ensembles.

The signs of asignifying semiotic machines are "sign-points." Partly they are of a semiotic order, partly they intervene directly in a series of material machinic processes (for example, the code number of a credit card that makes a cash machine work).

Asignifying semiotic figures do not secrete only significations. They issue starting and stopping orders and, above all, they provoke the "setting into being" of ontological universes. An example may be found at present, in pentatonic musical ritornelli that, after a few notes, catalyze the Debussyan universe, with its multiple components:

> The Wagnerian universe around Parsifal, which is linked to the existent territory constituted by Bayreuth;
>
> The universe of Gregorian chant;
>
> The universe of French music, with the rehabilitation of Rameau and Couperin for contemporary taste;
>
> The universe of Chopin, thanks to a nationalist transposition (Ravel, for his part, having appropriated Lizst);

Javanese music that Debussy discovered at the 1889 World's Fair; and

The world of Manet and Mallarmé, which is linked to his stay at the Villa Medici.

And to these present and past influences should be added the prospective resonances constituted by the reinvention of polyphony since L'Ars Nova, its repercussions on the French musical phylum of Ravel, Duparc, and Messiaen, and on the sonic mutation unleashed by Stravinsky, its presence in the work of Proust, and so forth.

Clearly there exists no biunivocal correspondence between, on the one hand, signifying linear links or links of *arché-écriture*, according to authors, and, on the other hand, this machinic, multidisciplinary, multireferential catalyst. The symmetry of the scale, transversality, the pathic and nondiscursive character of their expansion, all these dimensions get us out of the logic of the excluded third term and comfort us by the ontological binarism that we had previously denounced. A machine ordering, through its various components, tears away its consistency by crossing ontological thresholds, thresholds of nonlinear irreversibility, ontogenetic and philogenetic thresholds, thresholds of creative heterogenesis and autopoiesis.

It is the notion of scale that we should expand upon here in order to think fractal symmetries in terms of ontology. Substantial scales are traversed by fractal machines. They traverse them as they engender them. But it must be admitted that these existential orderings that they "invent" have already been there forever. How can we defend such a paradox? The reason is that everything becomes possible, including the recessive smoothing out of time described by René Thom, as soon as we allow for an escape from ordering outside of energy/space/time coordinates.

And there again, it falls to us to rediscover being's way of being – before, after, here and everywhere else, without however being identical to itself – of being eternal, of being processual, polyphonic, singularizable with textures that can become infinitely complex, at the whim of infinite speeds that animate its virtual compositions.

Ontological relativity sanctioned here is inseparable from an enunciative relativity. Knowledge of a universe in the astrophysical sense or in the axiological sense is possible only through the mediation of autopoietic machines. It is fitting that a foyer of self-belonging should exist somewhere so that whatever entity or whatever modality of being might be able to come into cognitive existence. Beyond this coupling of machine and universe, beings have only the pure status of virtual entities. The same goes for their enunciative coordinates. The biosphere and the mecanosphere, clinging to this planet, bring into focus a spatial, temporal, and energetic point of view. They make up an angle of constitution of our galaxy. Outside this particularized point of view, the rest of the universe exists – in the sense that we apprehend existence here below – only through the virtuality of the existence of other autopoietic machines at the heart of other biomecanospheres sprinkled about the cosmos. Even so, the relativity of spatial, temporal, and energetic points of view does not cause the real to dissolve into a dream. The category time dissolves in cosmological reflections about the big bang, while the category of irreversibility is affirmed. The residual object is the object that resists being swept away by the infinite variability of the points of view by which it can be perceived. Let us imagine an autopoietic object whose particles might be built on the basis of our galaxies. Or, in the opposite sense, a cognitivity constituting itself on the scale of quarks. Another panorama, another ontological consistency. The mecanosphere appropriates and actualizes configurations that exist among an infinity of others in fields of virtuality. Existential machines are on the same level as being in its intrinsic multiplicity. They are not mediated by transcendent signifiers subsumed by a univocal ontological foundation. They are themselves their own material of semiotic expression. Existence, insofar as it is a process of deterritorialization, is a specific intermachinic operation that is superimposed onto the advancement of singularized existential intensities. And, I repeat, there exists no generalized syntax of these deterritorializations. Existence is not dialectic. It is not representable. It is hardly even livable!

Desiring machines, which break with the great social and personal organic balances and turn commands upside down, play the game of the other upon encountering a politics of ego self-centering. For example, the partial drives and the polymorphously perverse investments of psychoanalysis do not constitute an exceptional and deviant race of machines.

All machinic orderings contain within them, even if only in an embryonic state, enunciative nuclei [*foyers*] that are so many protomachines of desire. To circumscribe this point we must further enlarge our transmachinic bridge in order to understand the smoothing out of the ontological texture of machinic material and diagrammatic feedback as so many dimensions of intensification that get us beyond the linear causalities of capitalistic apprehension of machinic universes. We must also surpass logic based on the principle of the third excluded term and on sufficient reason. Through smoothing out, a being beyond comes into play, a being-for-the-other, which makes an existing being take consistency outside of its strict delimitation in the here and now. The machine is always synonymous with a constitutive threshold of existential territory against a background of incorporeal reference universes. The "mecanism" of this reversal of being consists in the fact that certain discursive segments of the machine begin to play a game that is no longer only functional or significational, but assumes an existentializing function of pure intensive repetition, what I have elsewhere called a ritornello function. Smoothing out is like an ontological ritornello and, thus, far from apprehending a univocal truth of Being through *techné*, as Heideggerian ontology would have it, it is a plurality of beings as machines that give themselves to us once we acquire the pathic and cartographic means of access to them. Manifestations not of Being, but of multitudes of ontological components are of the order as machines – without semiological mediation, without transcendent coding, directly, as "given-to-being" – as Donor [*Donnant*]. To accede to such a giving is already to participate in it ontologically, by rights [*de plein droit*]. This term of "right" does not crop up here by chance, so true is it that, at this proto-ontological level, it is already necessary to affirm a protoethical dimension. The play of intensity within the ontological constellation is, in a way, a choice of being not only for itself [*pour soi*], but for all the alterity of the cosmos and for the infinity of time.

If there must be choice and freedom at certain "superior" anthropological stages, it is because we shall also have to find them at the most elementary levels of machinic concatenation. But notions such as element and complexity are here susceptible to brutal reversal. The most differentiated and the most undifferentiated coexist amid the same chaos that, with intinite speed, plays its virtual registers one against the other, and one with the other. The machinic-technical world, at whose "terminal" today's humanity is constituting itself, is barricaded by horizons formed by a mathematical constant and by a limitation of the infinite speeds of chaos (speed of light, cosmological horizon of the big bang, Planck's distance and elementary quantum of action of quantum physics, the impossibility of crossing absolute zero). But this same world of semiotic constraint is doubled, tripled, infinitized by other worlds that, under certain conditions, ask only to bifurcate outside of their universes of virtuality and to engender new fields of the possible.

Desire machines, aesthetic creation machines, are constantly revising our cosmic frontiers. As such, they have a place of eminence in the orderings of subjectivation, which are themselves called upon to relay our old social machines that are unable to follow the efflorescence of machinic revolutions that are causing our time to burst apart at every point.

Worldmaking as a Conceptual Framework for Computational Art [1]

Mark-David Hosale

> Every creator of sonic or visual art reveals and develops a framework. The harmonics of the framework in some sense mirror the complex structures which make us what we are and act upon our programs, regulating them according to each person's specific rhythms. - Nicolas Schöffer[2]

My interest in building a conceptual framework for computational art emerged out of a desire to develop a rigorous methodology that facilitates the integration of theory and practice in my creative process. This led to the development of a framework, called *WorldMaker Universe* (WMU), which provides a strong connection between the conceptual, software, and hardware components of my work.

The three parts of the WMU (operations, transforms, personae) are defined with the intention of abstracting out the computational and technical aspects of an artwork from its modes of expression. The decoupling of computation and technology from expression allows for modularity in the model. For example, two works may both use a similar algorithm to implement their inner logic (for example cellular automaton), but that logic could be mapped to pure sound in one work, or used to drive an immersive sculptural installation in another work. So, while seemingly dissimilar in their modes of expression, these disparate works can be quite comparable in terms of their computational bases. This kind of polymorphism is present in each aspect of the framework, which may be used to highlight convergent and divergent elements between disparate works.

This framework facilitates the creation of *immersive, transmodal artworks* that can be understood as *embodied ontologies*, or simply *worlds*.[3] In the context of computational arts, creative practice often engages methods that require both qualitative and quantitative approaches to its work. This framework is not a recipe for creating works, but a set of perspectives for reasoning about the concepts, implementations and aesthetics of works, and for discussion, reflection and debate of existing works.

[1] Much of this work was established in my dissertation, *Nonlinear Media as Interactive Narrative*, and this discussion is intended to be an extension of that work. see: Hosale, M.D., 2008. *Nonlinear media as interactive narrative*, University of California, Santa Barbara. http://gradworks.umi.com/33/30/3330491.html (accessed April 19, 2016.

[2] *Sonic and Visual Structures: Theory and Experiment Leonardo* (1985): 59-68.

[3] For the sake of clarity *world* (lowercase) is used in this writing to signify a *world* as a work of art. *World* (uppercase) is used to describe the entire reality we inhabit.

A note on theory

> What defines thought in its three great forms–art, science, and philosophy–is always confronting chaos, laying out a plane, throwing a plane over chaos. But philosophy wants to save the infinite by giving it consistency: it lays out a plane of immanence that, through the action of conceptual personae, takes events or consistent concepts to infinity. Science, on the other hand, relinquishes the infinite in order to gain reference: it lays out a plane of simply undefined coordinates that each time, through the action of partial observers, defines states of affairs, functions, or referential propositions. Art wants to create the finite that restores the infinite: it lays out a plane of composition that, in turn, through the action of aesthetic figures, bears monuments or composite sensations. – Gilles Deleuze and Félix Guattari[4]

[4] *What Is Philosophy?*, 1994:197.

As computational art is an inherently interdisciplinary practice, the theoretical basis for WMU adopts concepts and methodologies from several disciplines. Working with concepts across many disciplines is challenging. Each discipline comes with its own specialized terminologies, histories, and practices that have been developed to describe the idioms of its specialized discourse. Dealing with discipline-specific terminology in an interdisciplinary setting involves the comparison and translation of unique terms between disciplines, and demands an awareness of the false cognates and connotations that can arise when translating concepts from one discipline to another. A commonplace example of these false cognates lies in the use of the term *theory* itself. Theory has a general definition of being *an idea or set of ideas that is intended to explain facts or events*,[5] but how theory is formulated and applied depends greatly on the field of study.[6]

[5] Merriam-Webster. 2016. "Dictionary and Thesaurus - Merriam-Webster Online." Encyclopedia Britanica. http://www.merriam-webster.com/dictionary/theory. (accessed April 19, 2016)

[6] Even within a particular discipline the use of "theory" can be quite divergent already.

In philosophy, for example, a theory is a construct that ties together a collection of concepts/ideas into a system that is (ideally) internally consistent. Primary methods of inquiry include rhetoric, logic, and debate. This construct becomes the basis for describing the world (ontology) in terms of what we know and how we know it (epistemology), the ethical implications of this system (conduct, governance), and, important for those in the domain of arts, the definition and role of beauty (aesthetics). No discipline exists in an anechoic chamber, and philosophy (essentially being about the World itself) is a discipline that relies heavily on other disciplines to support its concepts. It needs examples from the World in order to ground itself.

Theory in art[7] is primarily concerned with the contexts and motivations for making art, as well as providing a basis for critique of existing art. Being that art in contemporary practice often has a strongly conceptual basis, this basis is often tied to ideas drawn from philosophical theory. Reciprocally, art can influence the discourse in philosophy as well. To this extent, it can be argued that art and philosophy are disciplines engaged in similar pursuits. Art and philosophy often converge, overlap, and inspire each other; the two fields often travel within the same territories, but using different vessels. The domains of philosophy (ontology, epistemology, ethics, aesthetics) have unfolded in various art movements that have emphasized formalized, testimonial, socio-political, and aesthetic assertions. An apparent difference between art and philosophy is one of approach. Philosophy develops through dialog and rhetoric (concepts), while art develops through expression (affects and percepts):

> Art and philosophy crosscut the chaos and confront it, but it is not the same sectional plane; it is not populated in the same way. In the one there is the constellation of a universe or affects and percepts; and in the other, constitutions of immanence or concepts. Art thinks no less than philosophy, but it thinks through affects and percepts.[8]

[7] I am relying on a vernacular definition of art. That is art as in painting, sculpture, photography, and related practices, which follow a similar discourse and methods. This is in distinction to the term arts, which includes art, music, theatre, dance, etc., i.e. the arts as a whole, which has many disparate discourses and methods.

[8] GIlles Deleuze and Felix Guattari, *What Is Philosophy?*, 1994:66.

The framing of this comparison of art and philosophy is important as it supports a practice of art making that is concerned with creating ontological propositions, in which the experience of art is intended to be a conceptual proposition that unfolds through percepts and affects (*worldmaking*).

The use of the term theory in music is radically different to theory in the domains of art and philosophy. Music theory is mostly concerned with analysis, including material relationships within a musical work and their organization from intervallic note relationships, conventional and newly created tonal and rhythmic systems, to structural elements that create the overall form of a work. Likely this difference exists because techniques employed in music theory are more closely related to logic and mathematics, as demonstrated by music's historically close relation to arithmetic, geometry, and astronomy (its study having origins in the quadrivium). Music is a craft based on musical systems and their constructs and music theory is very good at abstracting these systems into concise formal definitions.

By comparision music theory is an approach that describes *how* something is made, whereas art theory is an approach that describes *why* something is made. And while there are realms of discourse in music related to the question of *why*, they are not discussed in the domain known as music theory proper. The conceptual rhetoric of music exists in other forums, such as musicology.

It is significant to note that, in music theory, the tools that are used in the theoretical analysis of musical works are very often the same tools that are used to compose works as well. The act of composition involves composing a system, (to some extent) mathematical in nature, which is used to determine the outcome of a work. While highly technical, this system is typically abstract enough in its construct to produce many works. And in some cases, it even becomes the generative thread for musical forms, movements, and styles. The WMU uses music theory as a point of departure for its functional role in the process of developing work. It has a bidirectional relationship between theory and analysis of work, with the potential to generate forms, movements, and styles in computational arts.

The technical approach to the organization of the WMU also draws inspiration from theory found in software engineering. The logic and terminology of Object Oriented Programming (OOP) theory shares a common quality with music to abstract problems, and also uses the same methods it employs for analysis in the production of work. Object Oriented Programming is realized in a class of programming languages that are organized around objects, rather than "actions."[9] Objects group data structures into semantically simple blocks with procedures that are useful methods for working with these data. From these, larger objects can be built that again have methods for the data they contain. Repeatedly nesting objects within higher-level objects is intended to scale-up well to powerful applications. When following OOP practice closely, the resulting code should be easy to understand, reason about, test and further extend.

It is common practice in OOP to use a set of predefined abstractions known as design patterns, such those found in *Design Patterns: Elements of Reusable Object-Oriented Software*,[10] in software

[9] Gamma, Erich, Richard Helm, Ralph Johnson, and John Vlissides. 1995. Design Patterns : Elements of Reusable Object-Oriented Software. Addison-Wesley Professional Computing Series. Reading, Mass.: Addison-Wesley.

[10] Ibid.

development. These abstractions are not meant to be complete code examples, but are definitions of best practices within software engineering for common software design problems. One way of understanding the concept of design patterns is that they are descriptions of high-level patterns of structure that are commonly used, and therefore readily definable to fit many situations. The method whereby these patterns are described is known as a *pattern language.*

Pattern language is theory/method for system design adapted from Christopher Alexander's *A Pattern Language: Towns, Buildings, Construction.*[11] Originally a tool for abstracting common, repeatable forms and structures in urban planning and building construction, pattern language has proven to be efficient in describing many kinds of problems as abstract systems. In addition to architecture, urban design, and software engineering, pattern language has been applied to fields as wide ranging as biology,[12] human-computer interface design,[13] and business management.[14] For the WMU, pattern language has implications beyond the technical application of the software behind the work, extending to the entire formation of the work (and its analysis, as the case may be).

[11] Alexander, Christopher, Sara Ishikawa, and Murray Silverstein. *A pattern language: towns, buildings, construction. Vol. 2.* Oxford University Press, 1977.

[12] Helgesen, Carsten, and Peter R. Sibbald. "PALM-A Pattern Language for Molecular Biology." In *ISMB*:172-180. 1993.

[13] Tidwell, Jenifer. *Designing interfaces.* O'Reilly Media, Inc. 1999.

[14] Graham, Ian. *Business rules management and service oriented architecture: a pattern language.* John Wiley & Sons, 2007.

Worldmaker Universe (WMU) as a conceptual framework

> If art preserves it does not do so like industry, by adding a substance to make the thing last. The thing became independent of its "model" from the start, but it is also independent of other possible personae who are themselves artists-things, personae of painting breathing this air of painting. And it is no less independent of the viewer or hearer, who only experience it after, if they have the strength for it. What about the creator? It is independent of the creator through the self-positing of the created, which is preserved in itself. What is preserved – the thing or the work of art – *is a bloc of sensations, that is to say, a compound of percepts and affects.* – Gilles Deleuze and Felix Guattari[15]

[15] *What Is Philosophy?,* 1994:163-164.

The WorldMaker Universe (WMU) conceptual framework was developed to facilitate the creation of *immersive, transmodal* artworks that can be understood as *embodied ontologies*:

Figure 1. Hosale, M. D., *An Uncommon Affair At Tooting Bec Common* (2007 - 2010), http://www.mdhosale.com/rosemarybrown

An Uncommon Affair At Tooting Bec Common is an immersive cinematic work presented in an interactive installation environment. The story is centred around events that take place in the lounge of a medium, named Rosemary Brown, who channels deceased composers and writes down their latest works. Using an interactive interface the viewer controls the trajectory of the stories on four screens simultaneously through an ever-mutating storyline, which is revealed as they explore the story space of the film. The story is built of four story lines that follow the perspective of a different character in the film. The perspectives were strategically written so that the plot points of the stories can be interleaved, and presented backwards or forwards in time. The roles of the characters (i.e. protagonist or antagonist) and the unfolding of events of the story change depending on which story line is being followed.

Immersion: Immersion is not a strategy or technique, but a conceptual goal to completely engage a viewer in a work so it becomes *real* in the mind of the viewer. This is often done by saturating the senses of the viewer in artificially created environments, and/or virtual or mixed reality experiences. However, a larger discussion would include any mode of deep viewer engagement, which can happen in many more conventional (and less technologically induced) contexts (reading, listening, playing, etc.). The experience of immersion is ultimately one of perception and belief, which emerges in the viewer's mind. Viewer's actively support this experience by filling in gaps where details may be missing within a world to make it more believable. This is a phenonmenon known as the *suspension of disbelief.*[16]

[16] Murray, *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*, 1997:110.

Transmodality: Transmodality refers to a state of information whereby content becomes data, is abstracted, and becomes independent of its representation. In the digital domain, any data, regardless of its source (scientific data, internal states of algorithmic processes, sound, image, text), is encoded using the same underlying system-structured lists of numbers which have a certain meaning when machine-read in a certain way. To turn such abstract data into something humans can experience it needs to be represented in a perceptual modality, such as vision, sound, or touch. The point here is that one can choose to represent digitally encoded data in any modality, even in ones that differ radically from its original modality of creation. This separation of data from its possible perceptual/experiential representations is a key concept in the description of this framework.

Ontology and embodiment: The larger meaning of ontology in this discussion can be understood as an internally consistent system for explaining a subset of phenomena within a world. A world (in its ideal form) is a complex system that can be understood from the viewpoint of many potential ontologies. The whole sum of the potential ontologies within a world makes up a territory of conceptual planes, one that Deleuze and Guattari would describe as the plane of immanence:

> If philosophy begins with the creation of concepts, then the plane of immanence must be regarded as prephilosophical. It is presupposed not in the way that one concept may refer to others but in the Way that concepts themselves refer to a nonconceptual understanding. Once again, this intuitive understanding varies according to the way in which the plane is laid out.[17]

[17] Deleuze and Guattari *What is Philosophy* 1994:40

WMU *worlds* engage the entire sensorium of the viewer by immersing the viewer in the experience of an ontological territory. A viewer engages with an ontological territory in a modality that is primarily somatic and intuitive, leading to an embodied form of knowing; an embodied ontology. Through embodiment, knowing is no longer isolated to the mind, it becomes part of the entire sensorium.

> The difference between conceptual personae and aesthetic figures consists first of all in this: the former are the powers of concepts, and the latter are the powers of affects and percepts. The former take effect on a plane of immanence that is an image of a Thought-Being (noumenon), and the latter take effect on a plane of composition as image of a Universe (phenomenon). The great aesthetic figures of thought and the novel but also of painting, sculpture, and music produce affects that surpass ordinary affections and perceptions, just as concepts go beyond everyday opinions.[18]

Knowing and the expression of knowledge

One of the underlying themes that run through my work is a concern with knowing. How do we come to know something? How do we know we know? And, how do we express what we know to each other? In my dissertation, *Nonlinear Narrative as Interactive Media*,[19] the concept of knowing and the expression of knowledge are encapsulated in the term *narrative*. The etymological origin of narrative is found in the latin root *gnarus*, meaning: to have knowledge, to know.[20] The emphasis on narrative as knowing recognizes that the sharing of knowledge is an expressive act. The stories we tell each other and ourselves reveal the content and structure of how, what and why we know. Narrative is an expressive form of knowledge that not only reveals what is known about a subject, but also how that knowledge is structured, and how the teller interprets that knowledge.[21] From this perspective, the concept of narrative, and an analysis of how narrative unfolds, is an epistemological construct that describes the method of expressing and modelling of knowledge.

The specific focus in my dissertation on nonlinearity in narrative stems from a modern understanding of knowledge and nature. Recent paradigms in science and philosophy have changed our understanding

[18] Ibid:65.

[19] Hosale, M.D., 2008.

[20] McQuillan, Martin. 2000. *The Narrative Reader*. Psychology Press: 2 & 323.

[21] In support of this view, the significance of the connection between narrative and knowledge is recognized in the work of philosopher Jean-François Lyotard (1924-1998). As shown in his seminal text, *The Postmodern Condition: A Report on Knowledge*, Lyotard states: It is fair to say that there is one point on which all of the investigations [of knowledge] agree, regardless of which scenario they propose to dramatize and understand the distance separating the customary state of knowledge from its state in the scientific age: the preeminence of the narrative form in the formulation of traditional knowledge. Lyotard, Jean François. 1984. *The Postmodern Condition : A Report on Knowledge*. Theory and History of Literature; v. 10. Minneapolis: University of Minnesota Press:19.

of nature from a linear, hierarchical system to one that is structured along nonlinear representations of information, time, and space. The discovery that the underpinnings of the Universe behave in a manner contrary to linear logic and mathematics underscores the need for new approaches to the expression of knowledge that encapsulate nonlinear phenomena in a form that is scaled and transformed to the range of our perception.

Nonlinear narratives are also readily associated with digital technology, but have a history that is older than the digital revolution. Nonlinearity in narrative is ubiquitous in the context of digital culture, but was anticipated and developed for more than a century before the era in which the personal computer became an everyday household appliance. This is a well-trod history that has been described by many media theorists and philosophers including Marshall McLuan[22] and Frederich Kittler,[23] who recognize that there is a reciprocal relationship between rise in new media technologies and the acceleration of scientific advancement. As new media come into existence they change the way we interact with information, each other, and ourselves; they change the way we know. It is through technology that knowledge and information is created and disseminated, and with media technology this happens at a scale, form, and speed that was never possible before:

[22] McLuhan, Marshall. 1964. *Understanding Media; the Extensions of Man*. 1st ed. New York,: McGraw-Hill.

[23] Kittler, Friedrich A. 1999. *Gramophone, Film, Typewriter.* Stanford, Calif.: Stanford University Press.

<u>Nonlinear narratives are qualitatively *transmodal*</u>. Transmodality, as discussed above, describes the fluidity of new media, especially in the common baseline of the digital, and its ability to separate information from its representation. Information and its representation vary independently. This allows for the same content to be expressed through different modalities, and for a modality to express many different kinds of content.

<u>Nonlinear narratives are qualitatively *participatory*</u>. Transmodality and the ubiquitous access to large troves of knowledge through digital technology, such as the internet, gives rise to the notion that anyone can have equal read/write/copy access to information and its representation. Knowledge consumers and knowledge generators become the same, truth and opinions are weighed together as equal. It is the responsibility of the individual to subjectively filter and interpret what information is important or irrelevant, making their own path through the greater terrain of ideas (plane of immanence).

Figure 2. Crettaz , J.M. & M.D. Hosale, et. al., *Quasar 2: Star Incubator* (2012)
http://www.mdhosale.com/the-quasar-series

The Quasar Series (2007- 2013), is an iteration of immersive interactive light and sound installations, which included *Quasar*, *Quasar 2: Star Incubator*, and *Quasar 3 [danger du zero]*, was an iteration of immersive interactive light and sound installations that explore the world that exists beyond our senses by converging light and sound events in a tangible architectonic sculptural object. The name of the series is derived from a more or less mysterious astronomical occurrence, called quasars, which are understood to be extremely ancient and highly luminous events that occur in the furthest known reaches in our known Universe. The significance of quasars to the work is that they represent the edge of what can be seen and known, they are a demarcation of our epistemological horizon.

Nonlinear narratives are qualitatively *indeterminate.* Transmodality and participation give rise to the indeterminate nature of nonlinear narratives. As information is re-contextualized, augmented, and diminished through transmodal and participatory transformation, the structure of the information changes as well. Synchronous, asynchronous, convergent, and divergent patterns occur within nonlinear knowledge spaces resulting in an emergent (rather than predetermined) form.

Operations, Transforms, Personae

Given that goal of the WMU is to make worlds, it seems reasonable to develop this conceptual framework based on a theoretical model of our own World and on how we perceive it. Perceptual experience is the basis for all knowing given that all that we know and can know is acquired through observation (through our senses). Therefore the WMU functions as a model of knowledge (an epistemological model) based on an abstraction of what is known, knowable, and unknowable within our World in relation to our senses.

The WMU is divided into three parts: 1) *operations*, the systemic underpinnings of an ontological territory; 2) *transforms*, the shaping and expression of knowledge within that territory– how information is organized and presented, manifesting in a form that can expressed to others; and 3) *personae*, how that knowledge is perceived/experienced by an observer.

Operations represent the metaphysical space of a world before it is actualized. Operations attempt to encapsulate both what is knowable and unknowable within a world in a pure form of systems and data without a pereceivable representation. Operations do not become real until they manifest as something tangible to our senses through the process of transformation (described below). In Kantian terms, operations are the domain of noumenon (the thing in itself; Ding an sich), in a state of being (a priori) before it becomes something of experience (a posteriori) and appears to our senses:

> But the cause on account of which, not yet satisfied through the substratum of sensibility, one must add *noumena* that only the pure understanding can think to the *phaenomena*, rests solely on this. Sensibility and its field, namely that of appearances, are

> themselves limited by the understanding, in that they do not pertain to things in themselves, but only to the way in which, on account of our subjective constitution, things appear to us. This was the result of the entire Transcendental Aesthetic, and it also follows naturally from the concept of an appearance in general that some thing must correspond to it which is not in itself appearance, for appearance can be nothing for itself and outside of our kind of representation; thus, if there is not to be a constant circle, the word "appearance" must already indicate a relation to something the immediate representation of which is, to be sure, sensible, but which in itself, without this constitution of our sensibility (on which the form of our intuition is grounded), must be something, i.e., an object independent of sensibility. [24]

[24] Kant, Immanuel, Paul Guyer and Allen W. Wood (trans. and ed.). *Critique of Pure reason*. Cambridge University Press, 1998: 348.

In his *Critique of Pure Reason*, Kant questions whether or not we can really know anything beyond what appears to us through our senses. [25] Embedded within this critique, however, there is always some indication that there exists an aspect of the World that can never be sensed (unknowable). In order to have a complete World we must have a metaphysics that allows for both knowable and unknowable objects within that World. This is because what is known is not all that exists. We believe this because, through induction we are aware that there must be unknowable qualities of the World for it to be complete. It is the horizon of the unknown that shows us the limits of knowing, demarcating the epistemological territory that world contains and does not contain.

[25] Ibid. 338 -353.

In the domain of computation, noumena can be readily understood as processes and information in a complex of algorithms and data independent of sensibility and expression. This separation is useful as it provides a baseline for comparing seemingly disparate artworks that share similar noumena in the underpinnings of their approach. This has lead to the definition of a taxonomy of generative techniques (formalization, indeterminacy, combinatoriality) that can be used to categorize computational artworks, or for that matter any art practice that relies on generative techniques as part of their creation.

Formalized methods use nonlinear mathematics and algorithms to generate content that is typically expressive of a scientific concept or simulation as part of their motivation. Indeterminate processes include random and uncertain conditions to produce results that are unexpected

Figure 3., Hosale, M.D. *homunculus.agora* (2013 - 2014),
http://www.mdhosale.com/homunculus

homunculus agora (h.a) is a large-scale architectonic installation of several dozen sculptural bodies (homunculi) that are organized in a fluid-like cluster. The homunculi are implanted with electronic circuits that give them the ability to express behavioural qualities through light and sound events. A selection of the homunculi are touch sensitive and are positioned to invite people to touch the work. In doing so, the touch sensitive homunculi react with emotive sound and light responses. The name is derived from an alchemically made creature that looks like a miniature of its creator. This is a metaphor for the relation of the technology we create to ourselves, which is deeply connected to our bodies and the way we perceive the world. The term *agora* is a Greek word describing a place for gathering. The Homunculi gather in the museum to facilitate an exchange of emotive expression in an ecology of form, light, and sound. It becomes a gathering place for people to reflect on the connection we have with the environment and the world around us; a context for a marketplace of ideas.

and unrepeatable (but often under tight constraint). And, combinatorial processes involve the juxtaposition of disparate elements within a work in order to generate new cohesive wholes. Examples of types of operations can be found in the compositional approaches of Iannis Xenakis (formalization),[26] the methods of John Cage (indeterminacy),[27] and the game play of the Surrealist movement (combinatoriality)[28]. All of these techniques can vary independently of their representation allowing for the same process to be applied to different modalities independently. For example, combinatoriality is a widespread practice that has been applied in different domains under different names, such as collage (image), montage, (film), cut-ups (literature), and mash-ups (music), but in the end they are fundamentally the same process; the same taxonomy of operation.[29]

Transforms represent the metaphysical space of a world in the process of *actualization* and *virtualization*. A term derived from mathematics and engineering,[30] a transform in the context of the WMU is a function that changes the composition or structure of knowledge and information found outside of our limits of perception into something that is perceivable through processes of scale, translation, and mapping (actualization). Transforms also function in the inverse, taking information found in the real World and scaling, translating, mapping, and normalizing it so that it can be readily interpreted in the abstract domain of operations (virtualization).

A transform can be understood as an instrument, or a medium, that acts as a conduit of information from source to viewer. By way of example, an infrared telescope (and the systems that support it) is a transforms light captured from a distance and wavelength that falls well outside of our natural ability to perceive. Therefore, in order to understand the data captured by the infrared telescope it is necessary to filter, scale, and translate that data into the realm of our perception. The resulting expression of that data reveals previously unknowable distant space-time events originating from deep within our Universe. This would be an example of actualization as an action of making the imperceivable, perceivable; making the unknown, known.

The process of actualization can be understood in juxtaposition to the process of virtualization.[31] Derived from Bergsonian/Deleuzian concepts, the use of the virtual here is intended to describe the immaterial

[26] Xenakis, Iannis. 1992. *Formalized Music : Thought and Mathematics in Composition*. Rev. Stuyvesant, NY: Pendragon Press.

[27] Nicholls, David. 2007. *John Cage*. Urbana: University of Illinois Press.

[28] In particular games such as *The Exquisite Corpse*, as found in: Brotchie, Alastair, Mel Gooding, and Philip Lamantia. *A Book of Surrealist Games : Including the Little Surrealist Dictionary.* Boston: Shambhala Redstone Editions : Distributed in the United States by Random House, 1995.

[29] The applicability of these generative techniques to a broad range of arts and practices shows that the domain of computational arts is not necessarily limited to digital computing, and perhaps explains how the field of computational arts can have such broad implications across the arts. This would account for the inherent interdisciplinary nature of computational arts as well. I have already attributed the tendency towards a computational approach in the arts to having parallels to a modern understanding of knowledge and nature as described in the passage on nonlinear narrativity above.

[30] Merriam-Webster. 2016. "Dictionary and Thesaurus - Merriam-Webster Online." Encyclopedia Britanica. http://www.merriam-webster.com/dictionary/transform. (accessed April 19, 2016)

quality of the real, the unactualized qualities of an object; while the actualization represents the manifestation of an object, its becoming:

> The plane of immanence includes both the virtual and its actualization simultaneously, without there being any assignable limit between the two. The actual is the complement or the product, the object of actualization, which has nothing but the virtual as its subject. Actualization belongs to the virtual. The actualization of the virtual is [a] singularity whereas the actual itself is individuality constituted. The actual falls from the plane like a fruit, whilst the actualization relates it back to the plane as if to that which turns the object back into a subject.[32]

An alignment can be found between the Kantian notion of noumena and phenomena and the Deleuzian notion of the virtual and actual. In both concepts there is the notion of the unknowable, knowable, and known. In Kant, the unknowable and knowable make up the noumenological qualities of an object, while the known maps to the phenomenological. In Deleuze and Bergson the unknowable and knowable belongs to the virtual and the known to the actual. This epistemologically biased definition of actual and virtual is consistent because for Bergson and Deleuze the actual and virtual are just as much an abstraction of consciousness, image, and memory[33] as they are of physical reality. The distinction is that with Kant there is an implication that the relationship between noumenon and phenomenon is static. At least there is no explicit description in Kant's work of how noumenon and phenomenon might become another, or that it is even possible for these states to do so, whereas in the Bergsonian-Deleuzian view the relationship between the virtual and actual is constantly changing and evolving. So, while Kant's noumenon provides a clear description of the nature of operations and their processes, Bergson and Deleuze are needed here to describe the process of how operations are actualized[34] and become *real*.

Actualization is an intensive process where the domain of operations (noumena/virtual) becomes expressive. In Deleuze the relationship between the actual and the virtual is a dynamic relationship that exists like a circuit, one becoming another:

> You get to an inner circuit which links only the actual object and its virtual image: an actual particle has its virtual double, which barely

[31] The virtual as it is used here does not mean Virtual reality. Virtual reality (as in VR, a likely subject in the domain of computational arts) often implies the use of a suite of technologies in order to saturate a participant in a synthetic reality. Arguably, the result of the WMU framework is to be a vehicle to create works that are computational art worlds, and can be understood as a synthetic reality, even if these works do not employ the technology canonical to VR in their execution. However, the primary use of the virtual in the WMU is not a reference to a synthetic reality, but a reference to reality itself - as a reflection of the actual.

[32] Deleuze, *The Actual and the Virtual*, in *Dialogs* 1987:149-150.

[33] Deleuze, Gilles. *Bergsonism*, Hugh Tomlinson and Barbara Habberjam, trans. New York: Zone, 1991:112-113, among others.

[34] Both concepts are useful for the description of the relationship between operations and other components of the WMU framework, however Kant's phenomenology belongs to epistemology, providing a clear tie into the agenda of treating the WMU as a knowledge construct. Whereas, Deleuze's phenomenology belongs to psychology as well as other domains, which will become increasingly useful as the conversation shifts to the discussion of personae, and the phenomenological experience of worlds within the framework below.

> diverges from it at all; an actual perception has its own memory as a sort of immediate, consecutive or even simultaneous double. [35]

[35] Ibid.:150

Like operations, transforms are the subjects before experience, manifested in the domain of the perceivable, but not yet perceived. Based on this description transforms may seem like a form of operation, but should not be confused with operations as transforms do not produce knowledge objects on their own. Transforms function as a bidirectional conduit between personae and operations acting as an ambassador dedicated to the actualization (scale, translation, mapping) of knowable noumenon produced by operations, and the virtualization of real-World data found in personae. Transforms are the medium, the circuit itself.

Transforms are primarily kept distinct from operations and personae in order to facilitate transmodality in the WMU. Transforms are parametrically polymorphic, varying independently of operations and personae (described below), allowing for the transmodal interpretation of a particular event, or set of events, interchangeably. In design pattern language, the WMU is similar to a *Model-View-Controller*[36] structure where operations represent the *model*[37] and *state*[38] of the unfolding of the behaviour of a world, transforms represent the *controller*[39] and the *strategy*[40] that is used to interpret that state, and personae represent the *view*[41] and the *façade*[42] that is used to express and receive information exchanged with the real-World.

[36] Gamma, et. al. 1995:4-6.

[37] Ibid.: 4-6.

[38] Ibid.:305-314.

[39] Ibid.:4-6.

[40] Ibid.:315-324.

[41] Ibid.:4-6.

[42] Ibid.:185-194.

The domain of personae consists of percepts and affects and represents the metaphysical space of a world that is actualized through the expression of information, and virtualized via the collection of information from the real World. Beneath the experiential domain of personae lies a system that contains its virtual counterparts: operations and transformations as described above. Operations and transforms contain all potential states of the world throughout its existence, whereas the domain of personae represents a single expression of the state of the world at the moment of its actualization.

The use of the term personae in this model is meant to describe the image (or personality) of the WMU.[43] In a Jungian sense, personae do not present the entire inner workings of the WMU, but one possible face of those workings being presented to the World[44] at a given moment.

[43] Merriam-Webster. 2016. "Dictionary and Thesaurus - Merriam-Webster Online." Encyclopedia Britanica. http://www.merriam-webster.com/dictionary/persona (accessed April 19, 2016)

[44] see Jacobi, Jolande Székács. *The Psychology of Jung: An Introduction with Illustrations*. Yale University Press, 1973:26.

In the WMU this image/personality/face is defined as the *view*. The view is an expanded notion of viewing drawn from computer science design pattern terminology.[45] Viewing from this perspective includes the full spectrum of human sensation, such as the modalities of light, sound, taste, touch, and smell. Personae represent a subset of the world that includes the entirety of what is seen (through natural means, or via an extension of ourselves), as well as what is currently unseen but is seeable and/or deducible.

[45] Gamma, et. al., 1995:4-6.

At any given moment, personae present a limited view into a larger territory of the potential world. As described above, the territory of the world must seem larger than the view and beyond the reach of the viewer in order to create a sense of a complete world. This vastness is intentional and, when perceived by the viewer, results in a sublime experience of a world that is key to the experience of immersion.

The experience of immersion is one of the major goals of the WMU. In order for the WMU to become a world, it must be possible for the viewer to be saturated in the experience of the world and inhabit that world. But to complete this experience, it is ultimately necessary to rely on the ability and willingness of the viewer to engage with this world:

> The pleasurable surrender of the mind to an imaginative world is often described, in Coleridge's phrase, as "the willing suspension of disbelief... But this is too passive a formulation even for traditional media. When we enter a fictional world, we do not merely "suspend a critical faculty; we also exercise a creative faculty. We do not suspend disbelief so much as we actively *create belief* Because of our desire to experience immersion, we focus our attention on the enveloping world and we use our intelligence to reinforce rather than to question the reality of the experience.[46]

[46] Murray, *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*, 1997:110.

An immersive artwork therefore can be judged by how well it helps the participant *create belief*. In a cycle of reinforcement, the more immersed a viewer is in a work the greater their ability to create belief. In order to achieve deep immersion, worlds should engage the entire sensorium of the viewer by integrating the body (embodied knowing) as well as the mind (intellectual knowing) in the experience.[47] In order to enhance this mind-body immersion, personae function as a bidirectional

[47] Approaches, such as somaesthetics, aimed at promoting and integrating the theoretical, empirical and practical disciplines related to bodily perception, performance and presentation, could be useful in developing the execution of such experiences. For more on somaesthetics see: Shusterman, R. 2013. "Somaesthetics: Thinking Through the Body and Designing for Interactive Experience." *The Encyclopedia of Human-Computer Interaction*, 2nd Ed. and Shusterman, Richard. 2012. *Thinking through the Body: Essays in Somaesthetics.*

exchange, a transaction, between the WMU and the World around it. For this reason the notion of viewing also describes what is sensed by the WMU (virtualization) in addition to what is presented (actualization). Personae can be understood as a body of the world itself. In order to be believable the world has to be eversive,[48] have agency, be embodied in the experience as well; it must enact on the viewer as much as the viewer acts upon it.

[48] Novak, Marcos. 2002. "Speciation, Transverence, Allogenesis: Notes on the Production of the Alien." *Architectural Design* 72 (Part 3):68.

A further extension of the term view includes any stakeholder in an experience, such as humans, the environment, any living beings, and machines that are engaged in a feedback loop of immersion with the WMU.

The combination of the elements of the WMU (operations, transforms, personae) and the feedback relationship with the viewer is qualitatively a second-order cybernetic system.[49] The incorporation of cybernetic theory into this work is inspired by N. Katherine Hayles' book, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*.[50] Hayles describes the rise of human-machine integration through the history of cybernetic theory. Hayles' book provides a critique of technology as moving us culturally away from a natural self, to a disembodied self, losing subjectivity as our intelligence is co-produced with intelligent-machines (a.k.a. the posthuman condition).

[49] For more on second-order cybernetic systems see: Von Foerster, Heinz. "Cybernetics of cybernetics." *Understanding understanding: Essays on cybernetics and cognition* (2003):283-286.

[50] Hayles, University of Chicago Press, 2008.

The inclusion of cybernetics as an integrated model of embodied and intellectual knowing in the description of the WMU is done in conscious resistance to this tendency. The WMU seeks to develop systems of human-machine integration that engages the mind and body as an embodied intelligence that is not isolated to the brain, but is inclusive of the body and the environment.

In the domain of personae, viewing is a process of creating belief, but also one of creating experience. Experience is defined through a series of percepts and affects capable of expressing embodied ontologies. Being that viewing is a feedback system, the viewer creates percepts and affects as much as they are generated by the WMU. The formation of percepts and affects within the world is the result of a circuit between the viewer and the WMU; a cybernetic bi-directional exchange.

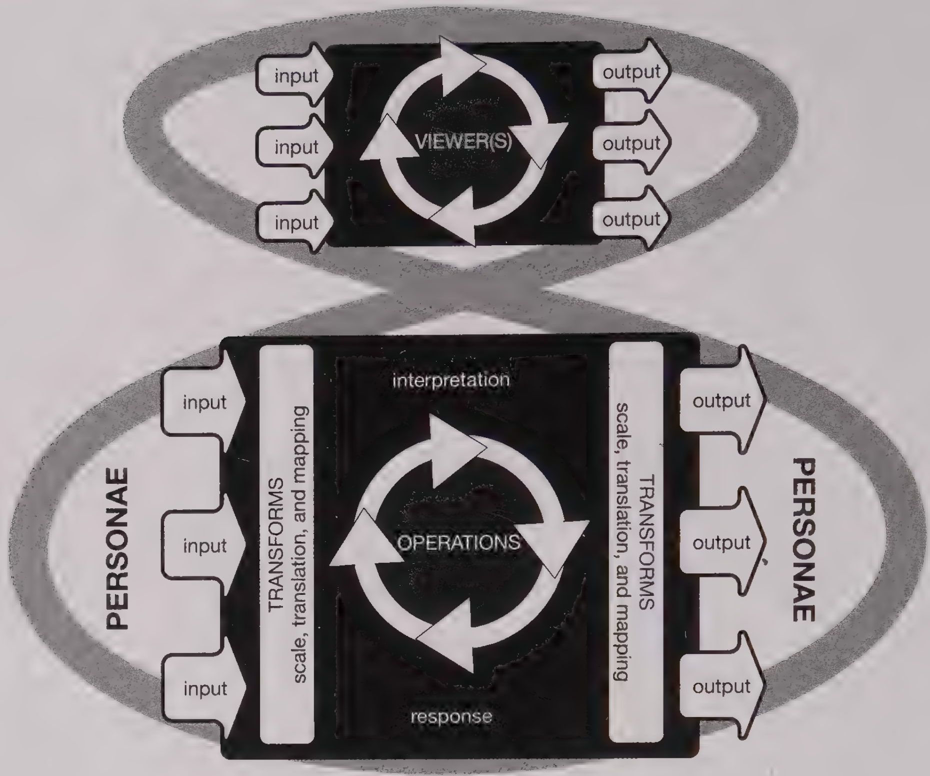


Figure 4. WorldMaker Universe as a 2nd-order cybernetic system.

Practical Implications

The following sections provide an overview of the practical implications of the conceptual framework described above, which include the use of the WMU as a software and hardware framework, and as a tool for the analysis of other works. The software and hardware tools described below have been used to implement many of my works including *An Uncommon Affair At Tooting Bec Common* (2007 – 2010; Figure 1),[51] *The Quasar Series* (2007-2013; figure 2),[52] and *homunculus.agora* (2013-2014; Figure 3)[53]. The description of the software (also called WMU) is a summarization of the complete system, with some minor refinements, previously described in my dissertation.[54]

The hardware implementation (*n*D::node)[55] represents new work that has been developed since the publication of my dissertation. The goal of the hardware framework is to provide a modular platform for

[51] http://www.mdhosale.com/rosemarybrown (accessed April 30th, 2016)

[52] http://www.mdhosale.com/the-quasar-series (accessed April 30th, 2016)

[53] http://www.mdhosale.com/homunculus (accessed April 30th, 2016)

[54] Hosale, M.D., 2008:83-111.

[55] Mark-David Hosale "nD::node, Hardware Platform for the Development of Computational Artworks," nD::StudioLab main website, accessed April 30th, 2016, http://ndstudiolab.com/projects/ndnode

bi-directional feedback between the software system and the physical environment. Much of the development of the *n*D::node has been empirical, i.e. driven by the needs of a particular work/application, but has been developed with the intent of supporting the WMU and being a physical counterpart to the WMU.

The final section describes the potential of the WMU as a tool for the analysis of other works. While it has been used to analyse my own work,[56] the WMU has never been used as analysis tool for the works of other artists. Therefore the section provides an overview of the potential of the WMU for analysis by comparing it to similar frameworks that are used in the analysis of various works.

[56] Hosale, M.D., 2008:140-177.

Software Implementation

From a practical point of view, the WMU as a software framework facilitates the creation of expressive and emergent behaviour in interactive installation environments by encapsulating commonly used elements of the software design of interactive environments into a ready to use set of abstractions. The implementation of the WorldMaker Universe as software is based on a modular system that can function as a distributed suite of applications. A large portion of the concepts and terminology that help define this framework are taken from design patterns, as used in computer science since *Design Patterns: Elements of Reusable Object-Oriented Software.*[57]

[57] Gamma, et. al.:1995.

The design of the *Universe* framework is based on an augmentation of the commonly known *Model-View-Controller* (MVC) design pattern (Figure 5).[58] The intent of the MVC is to organize an application into three areas that focus on the application logic (Model), user input and display (View), and the control mapping (Controller), which is responsible for maintaining the communications between the model and the view.

[58] Ibid.:4-6.

The primary additions to MVC help define the WMU framework more specifically in terms of the technologies and protocols required for its implementation. The WMU framework is not a standalone API or software framework, but is built upon common media oriented frameworks and toolkits found in computational art, such as OpenFrameworks,[59]

[59] http://www.openframeworks.cc (accessed May 15th, 2016)

OpenSoundControl,[60] MySQL,[61] etc., which contain the basic elements of this system, but require augmentation in order to satisfy the needs of the WMU. The following is not a comprehensive model, but an overview of key elements needed to implement the WMU.[62]

[60] http://www.opensound-control.cc (accessed May 15th, 2016)

[61] http://dev.mysql.com (accessed May 15th, 2016)

[62] For a more comprehensive model see: Hosale, M.D., 2008.:83-111.

Model

Operations, as described in the conceptual model of the WMU framework, are implemented in the Model component of the software framework. The Model contains all of the processes that are used to determine the unfolding logic of the world based on the generative techniques of formalization, indeterminacy, and combinatoriality as described above. The Model also makes decisions about what events to play and when they should be played. The Model uses internal algorithms, data gathered from databases, and virtual representations of the view components to determine these actions. All of the information processing and representation of the installation components within the Model is intended to be abstract in order to keep the data model and the representation of the data as separate as possible. Again emphasizing variability and independence facilitates scalability and the reuse of the same model in various types of works.

Databasing

Query is a database class that provides an interface to querying the database engine being used by the Model, such as scenes, histories, sequences, or any other data used by the WMU. Databases are primarily responsible for the storage and retrieval of event sequences and data type definitions, which are used by the view classes for the execution of state and transition updates.

Events

Event is an event handler class that handles the sequencing of events. This can happen through a generative algorithm, a sequencer, or a combination of the two. Event handling is realized as a Composite pattern that organizes events into hierarchical structures for clarity and modular transformation (Figure 6). Playback is achieved through a recursive unraveling of a sequence's branches and executing the events at the indicated relative time-point.

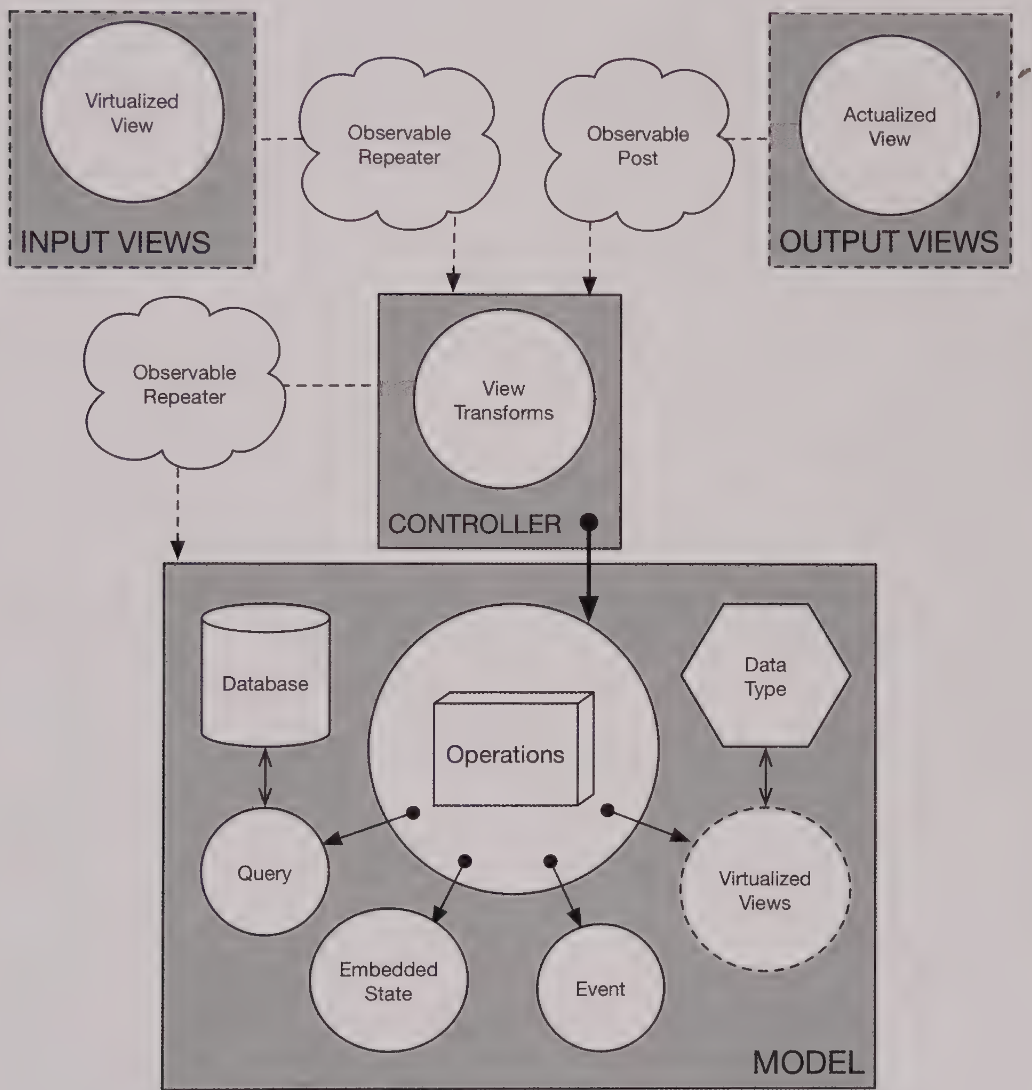


Figure 5: The WMU framework designed for the development of computational artworks.

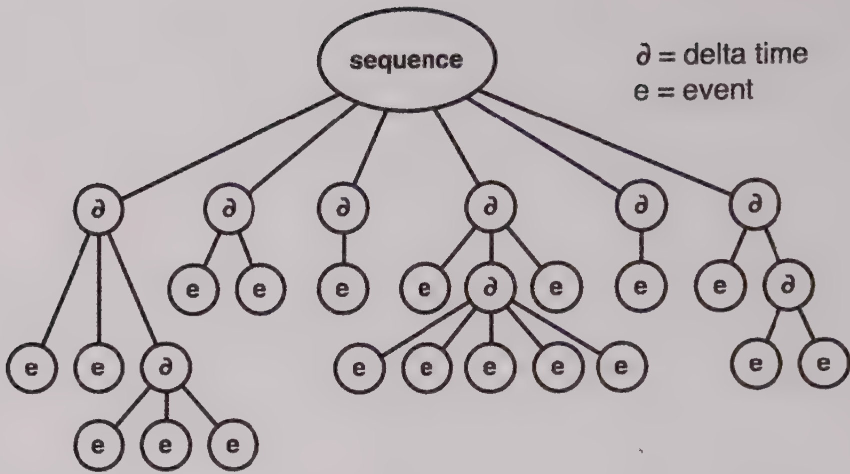


Figure 6: Diagram of the Composite Pattern Sequencer, which manages the unraveling of hierarchical events in time.

Embedded State Machine

The *Embedded State Machine* (figure 7) is responsible for keeping track of changing state, and determining transitions between events. The Embedded Transition State is governed by the operations of the WMU world. From the point of view of the conceptual model the Embedded State Machine is part of the responsibility of the transforms as it is used to interpret how state changes will be executed, acting as the glue for actualized events from the operations to the views. From a design pattern perspective, this is modelled as a combined *state*[63] and *strategy*[64] pattern, which facilitates the encapsulation of various logic systems, and various groupings of independent logic systems for the execution of states and transitions.

[63] Gamma, et. al. 1995:305-314.

[64] Ibid.:315-324.

Controller

The controller handles mapping, scaling, translation, and routing from the Views to the Model. From the point of view of the conceptual model the controller falls in the domain of transforms maintaining a tight connection between the virtual and actual aspects of a view to complete the circuit of information flow between these domains.

Views

View classes contain the logic of the various views of the personae of the WMU. Views consist of anything that an end user makes contact with within the physical and virtual space of the world. Views are defined as either input or output views. It is not unusual for an object or system to be composed of several input and output views. In this case, feedback is handled through the Model and Controller.

Views are designed to be as independent as possible of the software that implements the Model and Controller of the framework to facilitate the potential of Views being distributed among several applications and/or computers. To maintain this independence, views have virtual counterparts that are implemented in the Model and often have specialized data types associated with them in order to keep track of their type and state. This virtual model is also used to facilitate feedback between the views.

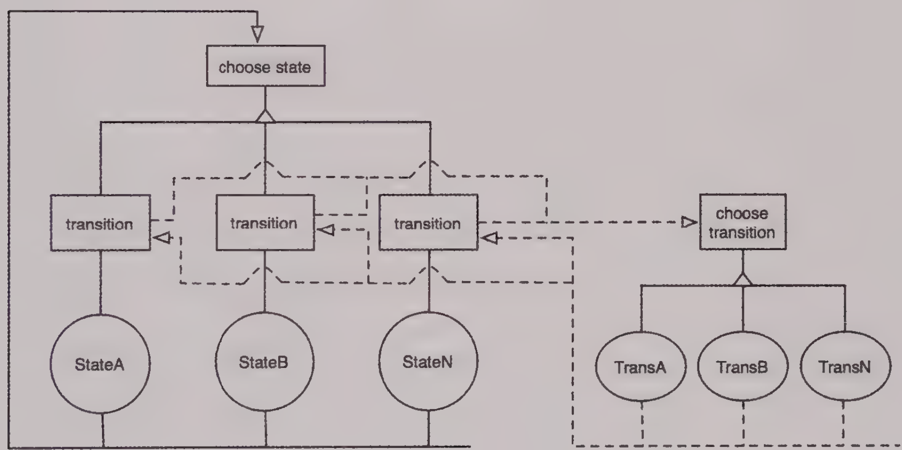


Figure 7: Diagram of the Embedded State Machine.

Hardware Implementation

The desire to develop a physical/hardware implementation of the WMU led to the creation of a custom designed microcontroller platform, called the *n*D::node.[65] The *n*D::node is a low-cost, Arduino-based hardware platform[66] developed to facilitate the creation of scalable, component-based media art works at architectonic scale. The *n*D::node forms a networkable system capable of handling hundreds of nodes that

[65] http://ndstudiolab.com/projects/ndnode.

[66] http://www.arduino.cc (accessed May 15th, 2016)

can be spread over large distances providing control (via LED's and actuators) while receiving real-time sensor data from the local environment (Figure 8). The result is a high-resolution bidirectional feedback system that can be embedded in the material systems of architectonic objects.

*n*D::nodes bridge the divide between the virtual and physical by providing a ready to use platform for sensing and actuation that can be used in conjunction of a wide rage of projects that require these technologies. *n*D::nodes could be integrated in every aspect of the interactive digital environments, including the walls,[67] ceiling, floor,[68] and in stand alone objects in the space. Results from this work could be equally applied to large scale installations and related projects that require large arrays of localized sensing and control, such as those found in the fields of architecture, computational arts, exhibition development, and related creative industries.

[67] http://mdhosale.com/interactivewall/ (accessed May 15th, 2016)

[68] http://mdhosale.com/protodeck/ (accessed May 15th, 2016)

*n*D::nodes are designed to be a modular with the intention that the modules can be adapted to different projects easily. In some projects modularity happens at the level of design and once manufactured the modules are populated on a single circuit board, such as with the *QYUnode* used in Quasar 2 and 3[69] (Figure 9). However, in projects such as *homunculus.agora*[70] this approach was not feasible due to the small space constraints of the piece and the larger circuit needed. It was decided to move some of the modules (such as sound, light, sensing) off board resulting in the system pictured in Figure 8. This multi-board modularity has other advantages as it allows for different *n*D::nodes to have different arrangements of modules in the same system. Additionally it allows for rapid prototyping of future projects through reconfiguration of existing modules, as it facilitates easy interfacing to new modules and prototype circuits.

[69] http://www.mdhosale.com/the-quasar-series (accessed May 15th, 2016)

[70] http://www.mdhosale.com/homunculus (accessed May 15th, 2016)

The resulting multi-board system is topologically very similar to the system developed by Robert Gorbet and Philip Beesley for the *Hylozoic Series* and related projects,[71] which, based on their publications, had an influence on the design of *n*D::node that predates our collaborations. However, there are major differences in the communications system and the logic and organization of the boards, which I will not elaborate on here. Despite these differences the *n*D::node is compatible with the

[71] Gorbet, Robert and Philip Beesley. 2007. "Arduino at Work, the hylozoic soil control system" In *Mobile Nation*, edited by Martha Ladly and Philip Beesley, Waterloo, ON Canada: Riverside Architectural Press.

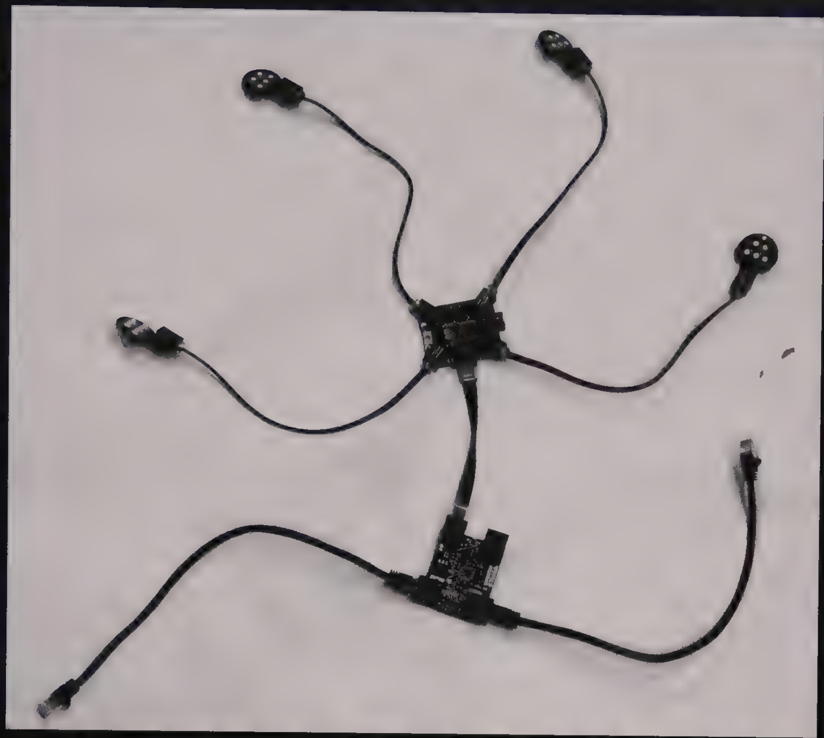


Figure 8. Overview of the *n*D::node system as used in *homunculus.agora*. ©M.D. Hosale 2014.

Figure 9. QYUnode, and *n*D::node variant. ©M.D. Hosale 2014.

Hylozoic system. *n*D::nodes were integrated into the *Hylozoic* system for a performance given at DEAF 2012.[72] Since that collaboration we have been sharing ideas around the design of the boards in the two systems.

[72] http://ndstudiolab.com/projects/evening-of-philip-beesley/88-evening-of-philip-beesley-deaf-2012 (accessed May 15th, 2016)

As a tool for analysis

In addition to being a tool for the creation of computational artworks, the WMU has the potential to be a method for analysis. There is a need in computational art for descriptors that extend beyond the experiential qualities of a work (personae) and look at the generative processes (operations) and structure of information (transforms) that inform the behaviour of a work. The separation of these characteristics in the WMU lend themselves well to comparing experientially disparate works that share common approaches in their operational and transformational application.

While the development of frameworks like the WMU for the creation of computational artworks is fairly common, few examples exist that apply similar tools in analysis. One of the closest examples is *A framework for understanding generative art*[73] (FUGA)[74]. Like the WMU, the FUGA separates processes and the transformation of data from its expression.[75] Where the WMU framework has three categories: operations, transforms, personae; whereas the FUGA framework has four: entities, processes, environmental interaction, and sensory outcomes.[76] While there are differences in the language used in the WMU and FUGA, their approaches to analysis are quite similar between the two.

For a start, operations of the WMU and entities of FUGA are similar in their description. Both terms represent the domain of unactualized generative algorithms independent of expression.[77] Knowledge objects (Ding an sich) in the WMU are *entities* in FUGA, with a distinction made between those entities that are readily apparent and those that are not (noumena).

The nature of knowable and unknowable noumena is highlighted in the *processes* of the FUGA. Here again we see parallels with the role of transformations in the WMU in the recognition of the role of processes

[73] Dorin, Alan, Jonathan McCabe, Jon McCormack, Gordon Monro, and Mitchell Whitelaw. "A framework for understanding generative art." *Digital Creativity* 23, no. 3-4 (2012):239-259. It should be noted that the FUGA does not use the term computational art, but instead uses the term generative art. As used in this framework, the term computational art is quite similar, in spirit, to generative art. The real difference is the larger goal of the WMU, being worldmaking, whereas in the FUGA the focus is on the generative methodologies. Despite this difference - both systems could be used for the other purpose and are quite comparable in their approach.

[74] My acronym.

[75] Dorin, et. al.:239.

[76] Ibid.:244.

[77] Ibid.:245-246.

in actualization: "…there is not necessarily a direct relationship between entity properties and the perceived outcomes of a generative artwork; these properties are often perceived only via a mapping."[78]

[78] Ibid.:244

The biggest difference that remains, at least on first glance, is the absence of a representation of personae within the FUGA. Instead, the FUGA divides personae into two distinct domains: environmental interaction, and sensory outcomes.[79] Clearly these domains map readily to input and output views. However, the WMU takes these concepts further by attempting to abstract modes of interactions, and the concept of agent, agency, subject and observer as an experiential domain of percepts and affects.

[79] Ibid.:246-247.

The parallel nature of these two approaches emphasizes a common need for analysis tools that take into account the behavioural qualities of a work, as well as their conceptual underpinnings. Where these approaches begin to diverge is in the WMU's metaphysical description of the framework as a system itself. This level of description is absent from the FUGA. This is likely a symptom of the differing goals of the two approaches. The initial goal of the WMU is in the creation of works, and in that goal there is an attempt to encapsulate the conceptual motivations of making a work as an embodied ontology. And by further extension of the concept of worldmaking, to address how these works can become worlds, through the immersion of body and mind in the experience. By encapsulating these conceptual motivations with a practical framework the ultimate goal of the WMU is to infuse the making of work with the process of concept building (*techné*).

This comparison is not intended to advocate one approach over the other, but to recognize the similarities and to show the potential of this kind of approach in the analysis of generative/computational art. Assuming the goal of the FUGA (at least as presented in the aforementioned publication) is solely to be used as a tool for analysis, it is important for the FUGA to remain more general in its descriptions and approach. So while the approach of the WMU is more expansive in its definition, it could prove to be more cumbersome for the general analysis of other works unless those works had an agenda of worldmaking at their core.

The scope is narrow because the WMU framework is the product of a single artist's practice, whereas the FUGA is derived from the intersection of a number of researchers' contributions. That being said using the WMU as a tool for analysis would be a valuable pursuit in finding qualities in works that align with its more specific approach, if not other reason than to help improve the WMU itself.

The FUGA has been given a large amount of attention because of the high degree of alignment between the WMU and the FUGA. Besides the FUGA there are a number of compelling texts that address the role of frameworks in making computational art. One example can be found in the anthology, *Interacting: Art, Research and the Creative Practitioner.*[80] The chapter by Linda Candy, *Research and Creative Practice*,[81] discusses art-making in terms of a research practice that is founded on conceptual frameworks at the core of their development and outcomes. Research-creation[82] is another way of framing the goal of integrating making and thinking as a single action in the creation of work. Another work, *What Is Generative Art?*[83], by Margaret Boden and Ernest Edmonds (one of the editors of *Interacting: Art, Research and the Creative Practitioner*) analyses the history of terminology, aesthetics, and varying practices within the field of generative/computational art.

Other work in this area that is notable includes approaches that use narrativity as a tool in understanding the form and structure of computational art works. Examples include, Brenda Laurel's *Computers as Theatre*,[84] Janet Murray *Hamlet on the holodeck: The future of narrative in cyberspace*,[85] Mark Meadows' *Pause & effect: the art of interactive narrative*,[86] and Mitchell Whitelaw's, *System stories and model worlds: A critical approach to generative art.*[87] All of these works, with the exception of the last, had a direct influence on the development WMU in its early stages.

Conclusion(?)

Based on a model of knowledge, the WorldMaker Universe (WMU) provides an abstract framework as a vehicle for the creation of immersive, transmodal artworks that can be understood as embodied ontologies (or worlds). This discussion has shown the potential for this framework, and

[80] Candy, Linda and Ernest Edmonds. eds. *Interacting: Art, Research and the Creative Practitioner.* Libri Publishing, Oxford, U.K., 2011.

[81] Ibid.:33- 57.

[82] According to the Social Sciences and Humanities Research Council (SSHRC) of Canada, research-creation is: An approach to research that combines creative and academic research practices, and supports the development of knowledge and innovation through artistic expression, scholarly investigation, and experimentation. Source: http://www.sshrc-crsh.gc.ca/funding-financement/programs-programmes/definitions-eng.aspx

[83] Boden, M.A. and Edmonds, E.A., 2009. "What is generative art?" *Digital Creativity*, *20*(1-2):21-46.

[84] Laurel, Brenda. *Computers as theatre*. Addison-Wesley, 1993.

[85] Murray, Janet Horowitz. *Hamlet on the holodeck: The future of narrative in cyberspace.* Simon and Schuster, 1997.

[86] Meadows, M.S., 2002. *Pause & effect: the art of interactive narrative*. Pearson Education.

[87] Whitelaw, Mitchell. "System stories and model worlds: A critical approach to generative art." *Readme* 100 (2005):135-154.

frameworks like it, in the conceptual and practical development of computational artworks, as well as in the analysis of existing works. In the end, this discussion is just a snapshot of an ongoing project that I will likely pursue for the rest of my life. In many ways it is an open-ended project with no real conclusion or goal.

The conceptual development of the WMU has been motivated by my interest in philosophy and my interdisciplinary approach to art making. Moving forward, it is my desire to use the WMU to analyse other works in order to further the WMU's conceptual development. Analysis is a new direction for this project and this discussion has helped push the WMU into this new domain. While this discussion made ground in defining the territory and potential of the WMU as an analysis tool, the inclusion of the analysis of another artist's work proved to be beyond the scope of this project. Therefore the practical application of the WMU as an analysis tool will be the subject of future publications.

As the conceptual qualities of the WMU are refined, the technical direction of the WMU progresses as well. Up until now innovation on the technical side of the WMU has developed empirically, primarily through the development of new artworks. This is for a number of reasons. The scale, cost, and time commitments involved in developing the WMU is extensive, and the opportunity to make art has proven the best means to further this project. But more fundamentally, there is a symbiotic relationship between the development of the WMU and the creation of my work. The WMU facilitates my creative process and enables the development of technically challenging works. As part of the development of my projects I always make an effort to refine the WMU. By increasing the usability and adaptability of the framework to new works I have managed to make a framework that is highly adaptable to my technical needs and refined for my conceptual approach

Once this project reaches a level of stability I could imagine making the software and hardware solutions discussed available to the public through a Creative Commons license. However, a major obstacle for me doing this is that I see my methods as highly idiosyncratic to my working style. Up until now, the best way I have found to share the WMU is through teaching, publications, and through the dissemination of the artworks themselves.

Techné and Dispositif of Architecture

Sang Lee

This chapter aims to discuss the current regime of *techné* by way of *dispositif*. The idea of techné today directly points to making and exercising such systems of relations, practices, and mechanisms: it has indeed opened up a new field of rationality. I begin the chapter by juxtaposing *techné* with *dispositif*. I will then attempt to situate the current digital/technological regime in relation to architecture as a kind of worldmaking practice. In the chapter I will touch upon some key concepts and apply them to architecture in regard to the potentials of tectonic composition. I will close the chapter with some thoughts and observations as to how *techné* as worldmaking is in fact establishing a mediative relationship with the natural world.

In the Western world, the notion of *techné* has evolved since the time of Ancient Greece, and continued to expand in terms of what it indicates. The ancient Greek *techné* (τέχνη) begins with "the woodwork of a *woven* house,"[1] involving communal effort. *Tekton*, the expert of *techné*, is a skilled carpenter who builds woven wood houses. Despite the ever-expanding range of criteria, techné has come to consistently indicate knowledge specific to a determinate subject matter and to the distinctive and specific objective of producing something functional and useful. It has been supposed to be teachable and learnable.[2] The tekton was also publicly recognized and sanctioned in some manner. This also indicates the possibility of retracting and revoking the public recognition. Unlike the fine arts, techné does not require a talent, but is conceptual, rational, and precise.[3] It had eventually come to include professions such as medicine and rhetoric, and become embedded in the fabric of the ancient Greek culture and society with some form of monitoring and regulation.

Today one of the defining markers of techné is how it looms over its historical double, episteme, the kind of knowledge that may not indicate such determinate, specific, qualifying criteria.[4] Thus while episteme may be indeterminate and speculative, techné indicates the kind of knowledge that arises from the practice of material production that involves an extensive array of tools and means external to the subject. Techné identifies the essence of the producing subject's relationship to material techniques and objects, and to nature, toward a specific kind of rationality. Therefore, the expanded role of techné "demands a capacity for

[1] David Roochnik, *Of Arts and Wisdom: Plato's Understanding of Techné* (University Park: The Penn State University Press, 1996). p. 19. (My italics).

[2] Aristotle states in general of science, "Further, every science seems to be teacheable, and what is scientifically knowable is learnable." *Nicomacchean Ethics* VI.3.§3.

[3] Roochnik, 1996. pp. 20-41.

[4] Ibid. p. 20.

intellectual solution to determinate tasks, some rudimentary knowledge of geometry or statics, in general *an ability to combine and improvise.*"[5] Techné means "to be able to coordinate its individual elements systematically toward a determinate goal remains the privilege of the expert."[6] In other words, long before Aristotle, techné was recognized as a special and specific form of knowledge. It was also viewed with suspicion. In *Republic*, Plato views music for example as potentially usurping the state's power and order due to its capability to arouse *emotional* tropes.[7]

[5] Ibid. p. 19 (My Italics).

[6] Ibid.

[7] Plato, *Republic*, trans. Allan Bloom, New York, Basic Books, 1968, 1991, 2nd ed., p. 101.

According to Aristotle, techné "… is a state involving true reason concerned with production."[8] On the one hand, Aristotle does not explicitly mention techné as pertaining specifically to particular manual professions or trades. Yet on the other, prior to the passage in *Nicomachean Ethics*, Aristotle distinguishes between production and action, stating that they are two different categories that are not interchangeable. Here it is important to note that Aristotle distinguishes *poiesis* from *praxis*. He states that "building for instance is a craft, and is essentially a certain state involving reason concerned with production."[9] What Aristotle states here, I believe, essentially points to the manner of poiesis that is defined by the approach or attitude inherent to the producer or the artist, not by the object or the thing that is produced.

[8]. Aristotle, *Nicomachean Ethics*, trans. Terence Irwin, Indianapolis: Hackett Publishing Co. 1999. p. 89 (Book VI, Chapter 4).

[9] Ibid. p.88.

Against the foregoing historical backdrop, in this chapter I will focus on today's technological apparatization and explore its entrenchment in what Michel Foucault characterized as *dispositif* and its codification. Foucault theorized that a dispositif is a system of relations that opens up "a new field of rationality and performs a dominant strategic function."[10] Subsequently, analyzing Foucault's dispositif, Giorgio Agamben claims further that a dispositif is "a set of practices and mechanisms … that aim to face an urgent need and to obtain an effect that is … immediate."[11] The idea of techné today directly points to the production and exercise of such ensembles of relations, practices and mechanisms, and furthermore that it has indeed opened up a new field of rationality. More importantly, today's ubiquitous digital media are an outcome of what I would characterize as a *dynamic* dispositif, in which both the virtual and the actual are intertwined with one another in a constant process of spatial and temporal negotiation without the possibility of stasis.

[10] Michel Foucault, "The Confession of the Flesh" In *Power/Knowledge Selected Interviews and Other Writings 1972-1977*, ed. Colin Gordon, New York: Patheon Books, 1980. pp. 194-228.

[11] Giorgio Agamben, "What is an Apparatus?" in *What is an Apparatus? And Other Essays*. Stanford: Stanford University Press, 2009. pp. 3-8.

Departing from Aristotle's notion of techné, I will first survey the key concepts that connect dispositif with techné, and lead to the notion of apparatus-centricity and apparatus-centric *codification* that defines today's worldmaking. Next I will explore the potentialities of techné-dispositifs and how architecture has in fact become a practice of creating, implementing, and above all managing ensembles of relations in a larger network of processes that produces built environments. Architecture today pertains more substantively to the codification of worldmaking, rather than to the direct authorial intent of built objects and environments that it used to historically. I will then conclude the chapter with some speculations that I believe may help establish a new field of considerations in architecture as a diegesis of worldmaking.

Heidegger's Ge-stell

In *The Question Concerning Technology*, Heidegger constructs his discourse on technology (or *die Technik*, the technics) around the notion of *Ge-stell*[12] in relation to Aristotle's techné. Heidegger's term, Ge-stell, most often translated as *enframing*, first indicates the pervasive nature of technological constructs in human society and is aimed at "the fundamental shift in people's relations with technology ..."[13] Heidegger distinguishes Ge-stell by setting out the fundamental notion of *en-framing*, in which "that *unconcealment* comes to pass in conformity with which the work of modern technology reveals the real as *standing-reserve*."[14]

Heidegger refers to, in essence, the imposing quality of technology that literally dominates and subjugates nature. By en-framing, nature ends up standing as a reserve and therefore ultimately being made redundant, even disposable. In this regard, worldmaking in Heidegger's Ge-stell indicates *unsecuring* and disclosing. According to Samuel Weber, "*technics* starts out from a place that is determined by that which it seeks to exclude."[15] The technics reveal the necessity of *disssimulation*. This in turn requires that technics is separate from *physis*, nature, and its self-emergent qualities. What sets physis apart from technics is "its impulse to open itself up to the exterior, to alterity."[16] While the kind of self-emergent qualities are intrinsic to nature, technics and technology by extension, as being intrinsic to man, are prescribed by

[12] The term *Ge-stell* is derived from the common German word *Gestell* that simply indicates a device that is designed to support something else (e.g. as used in *Tischgestell*, the table support) or to provide a physical structure or frame (e.g. as synonymous to *Rahmen*, the frame).

[13] Stuart Elden, *Mapping the Present: Heidegger, Foucault and the Project of a Spatial History*. London: Continuum, 2001. p. 75.

[14] Martin Heidegger, *The Question Concerning Technology and Other Essays*, William Lovitt, trans. New York: Harper & Row, 1977. p. 21 (My italics).

[15] Samuel Weber, Upsetting the Set Up: Remarks on Heidegger's Questing after Technics, MLN, Vol. 104, No. 5, Comparative Literature (Dec., 1989), pp. 977-992 (985) (My italics); Here Weber uses the terms "technics" instead of "technology" in that he believes the original term by Heidegger was never intended to mean technology. Barber contends that this is because Heidegger's text does not contain at all the kind of subject matters that are often associated with the word *Technology*.

[16] Ibid.

the rules that define, prescribe, and impose the boundaries or limits of its similitude. And such similitude is defined by the apparatus of exclusivity and therefore excludes the certain *alterity*, that is, what is outside of the techincs at hand, an artificial process of disclosing, producing, and en-framing, and of the matter and the agent.[17] Such dissimulation also distinguishes the temporal break that occurred from pre-modern (agrarian) to modern (industrial-machinic). While the agrarian model is regarded inherently in tune with nature, the modern technology of dissimulation and exclusion imposes its logic on nature. Thus nature is simply turned into a reserve to be exploited and to be subjugated to such exclusivity.

The notion of techné in the classical sense can be seen as the tekton's capability to reveal the essence human world, for example in Aristotle's Four Causalities. In Ge-stell Heidegger sees the opposite of what techné is supposed to be. In relation to the Four Causalities and the notion of *poiesis,* techné brings something into being in relation to self-emergent nature. Instead of disclosing the essence of techné, Ge-stell subjugates and obscures nature: "Thus when man, investigating, observing, ensnares nature as an area of his own conceiving, he has already been claimed by a way of revealing that challenges him to approach nature as an object of research, until even the object disappears into the objectlessness of *standing-reserve.*"[18]

Heidegger's notion of Technik and Ge-stell implies irreconcilable positions. Ge-stell that imposes the kind of insurmountable subjugation of nature and turns it into a reserve, *Ersatzteil*, so to speak, redundant and disposable, nonetheless provides a crucial view of how the *situatedness* of worldmaking may be further considered. While Hedegger's Ge-stell may be pessimistic of the technics and of its comprehensive subjectification of everything in its path, and at the same time to imply Ge-stell's enframing power and unsecuring-unsettling as clearly destructive, it offers a view in which such subjugating relations may be rerouted.

Themes on Dispositif

Michel Foucault's use of the term *dispositif*[19] is often translated as *apparatus.* The lexical sense of the word apparatus[20] denotes a set of

[17] As in the "Four Causes" in the Aristotelian sense.

[18] Heidegger, 1977. p. 19.

[19 The first documented instance of the term by Foucault appears, according to Paul Rabinow, in an interview with *Le Monde*, the French newspaper in 1975. (Paul Rabinow, Anthropos Today: Reflections on Modern Equipment, Princeton: Priencеton University Press, 2003. p. 49.) And in 1977, Foucalt provided an extended definition of the term in a conversation piece originally published in the journal "Ornicar?" of the department of psychology, University of Vincennes. The latter is subsequently translated and included in *Power/Knowledge: Selected Interviews and Other Writings* 1972-1977, ed. Colin Gordon, New York: Vintage Books, 1980. pp. 194-228.

[20]. *The American Heritage Dictionary of the English Language,* Fourth Edition 2007, 2000. Updated in 2009. Houghton Mifflin Company, p. 85; *Roget's II: The New Thesaurus, Third Edition by the Editors of the American Heritage Dictionary* 1995 by Houghton Mifflin Company. p. 43; WordNet Search - 3.1, http://wordnetweb.princeton.edu/perl/webwn?s=apparatus&sub=Search+WordNet&o2=1&o0=1&o8=1&o1=1&o7=1&o5=1&o9=&o6=1&o3=1&o4=1&h=00 (Accessed 21 Nov. 2011); http://dictionary.reference.com/browse/apparatus (Accessed 7 Dec. 2011); Online Etymology Dictionary; http://www.etymonline.com/index.php?allowed_in_frame=0&search=apparatus&searchmode=none (Accessed 7 Dec. 2011)

implements, tools, and bureaucracies that are directed toward accomplishing certain performative and operative purposes or objectives. The sense of the term dispositif in question here refers in contrast to an actively deployed system of interconnected conditions that situate a particular action and its consequences in aggregate terms that are pervasive or even ubiquitous, such as for example, various social and political institutions, juridical systems, means of sustaining and codifying such institutions and systems, and so forth.

While certain individuals may (appear to) exercise their freedom, such freedom is in fact *configurational*. It depends on the potentialities and the degree of exclusionary processes that may be inherent in the kind of discursive regime and matrix, within which the individual aggregates are suspended. The aggregation-matrix ensemble, in contrast to that of the singular yet fluid matrix, takes on an important set of ramifications and refers to an important shift in architecture as a discipline. It ultimately connects to the discipline's apparatization in a way that is comparable to what took place in the media dispositif – especially in what Marshall McLuhan characterizes as "hot media"[21] – in the pervasive appratization of culture.

[21] Marshal McLuhan, *Understanding Media: The Extensions of Man*, ed. W. Terrence Gordon, Berkely: Ginko Press, 2003. pp. 37-50.

First, the disciplinary apparatization process indicates a condition that is no longer autonomous, or considered authentic for that matter, in a historical sense. Today, the distinction of one discipline from the other largely depends on, and is relative to, the kind of apparatuses they share. Most decisively by means of the underlying codification systems, such apparatuses define the new layer of what I term the apparatus-centric culture. The codification defines and shapes the functioning of procedures and protocols, and thus determines the operability of a given discipline and its constituent agents and contingencies.

Second, aggregation and apparatization imply an incremental process of development in which variations and combinations provide the primary operative mode. This in turn intensifies the fragmentation of parts and makes the combinatorial operations and versioning the most crucial part of the composition as such. This is primarily afforded by the flexibility of the design and implementation of the codification system that ultimately decides the nature of the apparatus.

Third, the apparatus thus neutralizes by means of the kind of underlying codification systems the mediatic[22] specificity and differentiation, and becomes more fluid, horizontally distributed, and intermodal. The nature of what is known as a medium in a historical sense no longer requires, or at least no longer foresees, material physical manifestation. One kind of contents can, and often must, be easily transcribed and mutated onto another.

[22] "Mediatic" is not lexically defined. Here I use the term to indicate an adjective of "media" to denote "behaving like, or possessing and/or sharing the qualities of, (mass) media."

Apparatization can also be thought of as operative logic that blankets a given discipline and work. Such disciplinary apparatization is expected to perform certain functions or tasks with certain means in order to accomplish certain objectives. In architecture, such operative logic has been indeed the mode of *projection* embodied in the drawings that are constructed by projecting geometries, e.g. plans, sections, elevations, and perspectives. With the advent and proliferation of digital algorithmic *extensions,[23]* architecture has become thoroughly apparatized, the disciplinary field of which has come to include the ever more expansive elements, catalogues, modalities, and attributes.

[23] Michel Foucault, "Of Other Sapces," trans. Jay Miskowiec, *Diacritics*, Vol. 16, No. 1 (Spring 1986). pp. 22-27.

Dispositif [translated as *apparatus*] according to Foucault (1) is "a thoroughly heterogenous ensemble consisting of discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions" and "the system of relations that can be established between these elements"; (2) provides "a means of justifying or masking a practice which itself remains silent, or as a secondary re-interpretation of this practice, opening out for it a new field of rationality"; and (3) responds to "an urgent need."[24]

[24] Michel Foucault, *Power/Knowledge Selected Interviews and Other Writings*, ed. Colin Gordon, trans. Colin Gordon et al., New York: Vintage Books, 1980: pp. 194-228. (My italics.).

In the lecture "Of Other Spaces,"[25] delivered to a group of architects in Paris in 1967, Foucault already implied that architecture was a part of what he would later formulate as dispositif. In the lecture, Foucault defined three historical stages of spatial development: emplacement, extension, and site.[26] The space of extension, Foucault asserts, arises from Galileo's discovery of the solar-centric planetary system, which scientifically established the worldview that the universe is infinite and we are nothing but a point within it: the space extends infinitely. The space of site, Foucault explains, replaced that of extension

[25] Foucault, 1986. pp. 22-27.

[26] Ibid.

and "is defined by relations of proximity between points and elements". [27] And Foucault continues:

[27] Ibid. p. 23.

> Moreover, the importance of the site as a problem in contemporary technical work is well known: the storage of data or of the intermediate results of a calculation in the memory of a machine; the circulation of discrete elements with a random output (automobile traffic is a simple case, or indeed the sounds on a telephone line); the identification of marked or coded elements inside a set that may be randomly distributed, or may be arranged according to single or to multiple classifications.[28]

[28] Ibid.

Foucault's construct of dispositif, in relation to the notions of extension and site, helps situate the *instantiation* of architecture, and its urban conditions as accumulative manifestation of the relations of certain intents, regardless of the degree of coherence in articulation. Architecture and its urban conditions are the outcome of interconnected discourses, attributes, and practices that are instantiated and materialized. Internally, architecture as a discipline is dedicated to setting-up its own regime of dispositifs centered on the composition and the agency of its instruments.

Second, the substance of a given work of architecture is predetermined in terms of the relations and trajectories between what is made explicit (drawings and notations, specifications and writings of all sorts that in some manner bracket a given project) and what remains implicit (facts and conventions, intentions, desired effects or affectations, preferences, ownership, etc.).

Third, given its inevitable public presence and the assumptions about accommodating human activities and use, architecture is necessarily expected to be subordinate to the force-relations between an ensemble of discourses by institutions, politics and economies. This ensemble of force-relations determines the crucial facets of spatializing, the ordering of multiplicities in human society and ultimately the body.

Here, what pertains notably to architecture is that dispositif situates the discipline as a constituent in a system comprising elements and relations that used to lie outside what has been regarded as the historical disciplinary core. The disciplinary core of architecture in this regard consists of, not only the historical genealogy and sedimentation (i.e. the successive innovations that generations of architects and builders have inherited and extended), but also more importantly the means by which the discipline has instantiated and materialize its work (i.e. the conventions that have been built to codify the practice of architecture, or simply the way it was supposed to be done according to the cultural and social vernacular traditions).

In one instance, the architectural discipline has relied on the instruments that have been the de facto convention by means of projective spatial representation, most notably by the perspectival projection of Brunelleschi in the fifteenth century. Architectural drawings and notations have been the primary authorial instrument for conceiving, composing, disseminating, and communicating the architect's intent for the work of architecture. Such drawings and notations also indicate the architect's perception of this world and its creation for many centuries. Through the theoretical work of Alberti and the subsequent centuries' architects, the discipline has alternated between the technic and the epistemic. An architect is no longer a constructor of actual artifacts but rather an author of instructions that present the information necessary to execute the design's exact intent in material form: the apparatized turn.

In regard to the apparatized turn in architecture it is important to note also that by producing instructional and notational information, rather than participating in the material construction of the actual buildings on site, architects could engage in "a new field of rationality."[29] The apparatization process has opened up a new class or genre of architecture, which may be characterized as virtual and *allogenic*.[30] It exercises its own aesthetic and ideological power made possible by the projective apparatus.

Allogenic techné produces drawings and notations that inform a work of architecture as a location that is no longer an actual place. Rather, architecture as a Foucauldian site comprises the "relations of proximity between points and elements" removed from the immediate, actual locales. Thereby architects could engage in an aesthetic and authorial practice. This provides a more conceptual apparatus than the pre-apparatized way of building that relied on the process of construction *in situ*. In autogenic techné, the designer and the builder are one and the same. The building is *crafted* on-site at his discretion. In contrast, allogenic techné elevated the exclusivity of the abstract design process that gives shape to the architect's imagination, intent and rationality. An architect could remove himself from

[29] Foucault, 1980. p. 194-195.

[30] Mario Carpo adopts Nelson Goodman's "allography" and "allographic" (see Nelson Goodman, Language of Art: An Approach to Theory of Symbols, Indianapolis: Hackett Publishing, 1976). While the former addresses the descriptive and instrumental nature of the process, the latter points to an emergent one in that the medium of architectural composition generates the object.

the actualities of the not-so-ideal planes of site, materials, and construction, and focus instead on the conceptual enframing. The allotechnic process created a new class of architectural dispositif.

The composition and instantiation of music in the twentieth century by comparison provide not only the case for the dominant regime of music at the time, but also that of resistance against such dominant power dispositifs. First and foremost, we can cite the futurists' attempt to disrupt and dysfunctionalize the old regime of the time by empowering the notion of noise and dissonance. We can also examine the post-World War II composers' challenge against the historical conventions of music. In the 1950s and 1960s, we see aesthetic movements such as the Situationist International and the emergence of so-called performance art, of which proponents include, to name a few, Guy Debord, Josef Beuys, Nam Jun Paik, and John Cage. Such figures have called into question the cultural power of dispositifs of their time and subsequent generations. Their explorations follow a similar pattern of resistance against the dominant power-dispositifs by delving into the otherness, the alterity: Debord's Situationaist International and psychogeography; Beuys' performances involving felt and fat; Paik's performances and video art; and Cage's compositions exploring the contingent and the aleatory. More specifically pertaining to gender and female body as the very battleground of power, we can also cite Carolee Schneemann in her 1975 performance *Interior Scroll*. Subsequently, and perhaps in the most defining way, during the 1990s digital revolution propelled by the W3 standards, the digital impetus in architecture has appeared to foresee a new kind of architecture dispositif that was supposed to replace the composition of absolute geometry with the topological kind that was to fulfill the digital zeitgeist of Deleuzian techné, the rhizome and the fold. In Deleuze, Foucault's object-event[31] becomes objectile that is subsequently appropriated by the proponents of parametric, generative digital architecture. In this sense, techné-as-world-making enters the twenty-first century with a clear sight on the variability and a new form of autogenic techné.

The Foucauldian concept of dispositif presents many facets. Its first notable feature implies function and functionality as the most fundamental unit of a given dispositif.[32] By noting function as an inherent part

[31] Foucault, 1980.

[32] Michel Foucault, *The Archeology of Knowledge*, trans. A. M. Sheridan Smith (New York: Pantheon, 1972), 31-39, 79-105. Also see Neil Brenner "Foucault's New Functionalism" in *Theory and Society*, Vol. 23, No. 5 (Oct., 1994), pp. 679-709.

of dispositifs, Foucault again refers to a variety of constituents. In regard to functionality Foucault emphasizes – in *The Order of Things* preceding his conception of dispositif – identity and difference. The level of complexities determines the order of knowledge systems from the simple to the complex in relation to thoughts, rather than the previous historical systems that determined the order of things in terms of resemblance. Foucault contends that this modified the entire episteme of the Western culture.[33] Therefore, later what was to become dispositif indicates as its primary function, "the ordering of human multiplicities"[34] as a form of exercising power.

[33] Foucault. *The Order of Things: An Archeology of Human Sciences*. London: Taylor & Francis, 2005. pp. 53-55

[34] Michel Foucault, *Discipline and Punish: The Birth of the Prison*, New York: Vintage Books, 1995. pp. 215-220.

By devising a means of mediating the ideal state, the projective (and projected) drawings and notations, architects could assume the authorial power of their conceptual work and engage in the ordering of multiplicities and complexities arising from various human and material factors. This apparatized turn in architecture became decisive in the seventeenth century, and points not only to the disjoining of the discipline from the natural relations that were constructed based on similarities, affinities and analogies, but also more importantly to the establishment of the artificial relations, the apparatus and its codification.

The codification of architecture as (and as a part of) a dispositif by means of drawings and notations provided the architects with the power to impose and exercise a certain abstract intent in its logic. Rather than simply producing an object that responds to and accommodates the variables surrounding its materialization, and rather than conforming to the resemblances that has historically driven empirical craft, the seventeenth century architects, more than before, could firmly situate themselves as authorial figures in the conception, composition, and construction of architecture and yet largely extricate themselves from the vagaries of the construction trade. This is not to say that the architects were no longer involved in the construction process, but rather the nature of their involvement became focused on authoring and implementing abstract rationalities.

Giorgio Agamben summarizes Foucault's dispositif[35]:

a. a heterogeneous set that includes virtually anything, linguistic and non-linguistic ... discourses, institutions, buildings, laws, police measures, philosophical propositions and so on

[35] In the following paragraphs discussing Agamben's analysis of apparatus, I have attempted to distinguish dispositif (*dispositivo*) as a concept from apparatus (*apparato*) as a mechanical object. While he describes his reading of Foucault's dispositif (*dispositivo*), Agamben also cites and discusses various physical objects as *dispositivo*. He doesn't appear to distinguish between *dispositivo* and *apparato*. As I have argued elsewhere, the term apparatus or *apparato* indicates more specifically a collective or a set of mechanical functional devices. Therefore, in this part in certain paragraphs, I have used the term dispositif, while in others, apparatus. The original Italian title of Agamben's text in questions here is "Che cos'è un dispositivo?"

b. a concrete strategic function and is always located in a power relation

c. it appears at the intersection of power relations and relations of knowledge.[36]

Furthermore it is "a set of practices and mechanisms (both linguistic and non-liguistic, juridicial, technical, and military) that aim to face an urgent need and to obtain an effect that is more or less immediate."[37] It is crucial to note here that a dispositif appears at the *intersection* of power and knowledge, and that it is expected to serve an urgent need and to cause an *immediate* effect. While it is worth noting that it is necessarily a discursive organization of some sort, in today's digital context a dispositif should in fact be thought of as heterogeneous means and determinants of composing and instantiating work of architecture. The work of architecture in this case is also at an intersection of power and knowledge. It is made in order to cause an immediate effect. The intersection of power and knowledge for architecture comprises not only exercising one's own spatial contexts, both individual and collective, that are composed of cultural, social, economic and political elements (i.e. architecture has rarely been about or respected for providing only what is necessary), but also the notion that architecture constructs a particular kind of knowledge that runs in extremes of discursive formations.

On the other hand, for Agamben an apparatus implicates neither the right nor the wrong way to use it. This argument arises from the classification of living beings and apparatuses with the subjects suspended in the network of relations. According to Agamben, an individual, a substance, may take on "multiple processes of subjectification."[38] Furthermore, apparatuses appear at the root of the humanization process and from the human desire for happiness. Thus, he concludes, "The capture and subjectification of this desire in a separate sphere constitutes the specific power of the apparatus."[39] Specifically in regard to the technological apparatuses, according to Agamben, the capturing and subjectification processes of the apparatuses preclude the possibility of distinguishing the correct or incorrect way of dealing with them as we are all captured by and subjects of the apparatuses.[40]

[36] Giorgio Agamben, "What is an Apparatus?" in *What is an Apparatus? And Other Essays.* Stanford: Stanford University Press, 2009. pp. 2-3.

[37] Ibid. p. 8.

[38] Ibid. pp. 16-17

[39] Ibid.

[40] Ibid. p. 21.

Agamben's latter reference for an apparatus having to achieve an immediate effect for an urgent problem appears to relate to the overall functional tendencies of Foucault's dispositif-construct. In *Discipline and Punish*, Foucault's construction of dispositif centers around the ways and means with which the dysfunctional and the deviant elements of society are brought under control, and how space actually becomes one of the primary elements such dispositif should dominate.

Aside from discussions of so-called biopolitics and Foucault's discussions of subtractive modes of power dispositifs, the concept of dispositif is in fact spatial-functional. The power-resistance polarity is seen as inherent in dispositifs.[41] A power dispositif is composed of certain organized operations of social and political systems.[42] Foucault describes that there is always some sort of a primordial desire or urge for individuals, groups, and classes to escape the relations of power.[43] One example Foucault cites is the carnival "in which rules were inverted, authority mocked and criminals transformed into heroes."[44]

[41] Jürgen Habermas, "Questions Concerning the Theory of Power" & Fraser, "Foucault on Modern Power: Empirical Insights and Normative Confusions," in Michael Kelly (ed.), *Recasting the Foucault/Habermas Debate*, Cambridge: MIT Press, 1994. p 229.

[42] Peter Dews, "Power and Subjectivity in Foucault" *New Left Review*, 144 (Mar./Apr. 1984). p. 90.

[43] Foucault, 1980. p. 138.

[44] Foucault, 1995. p. 61.

[45] Agamben, 2000. p. 1.

[46] Ibid. p. 14.

Agamben characterizes dispositif as a "decisive technical term in the strategy of Foucault's thought."[45] He reiterates Foucault's view that his concept is, and should be, used as a toolbox. It should help reveal the kind of devices that serve as a matrix and aggregate certain strategic functions but kept out of active view. However, Agamben's own definition of the apparatus – "literally anything that has in some way the capacity to capture, orient, determine, intercept, model, control, or secure the gestures, behaviors, opinions, or discourses of living beings"[46] – expands the concept to all those who have the capacity to create the third class of beings, the subjects between the living-beings and the apparatuses. In this regard, Agamben enumerates such *things* as cigarettes, ink pens, and cellphones, as well as language itself as apparatuses of dispositifs capable of subjectifying and producing relations of power and subjugation in our modern epoch. In addition the subjectification is inherent in the seemingly benign processes that we voluntarily participate in for our own convenience and need.

In his essay *"What is a dispositif?"*[47] Giles Deleuze offers another view of Foucault's dispositif. Deleuze sets out to characterize the dispositif as tangible and multilinear, and states that its lines do not "outline or

[47] Timothy J. Armstrong (ed.), *Michel Foucault, Philosopher*, New York: Routledge, 1991. pp. 159-168.

surround systems which are each homogeneous in their own right…"[48] In a way re-reading Foucault's definition that was quoted earlier, Deleuze shifts the focus from the idea that a dispositif establishes relations and connections between the heterogeneous elements that constitute it, to the disjointed and in fact precarious character of such a formation. Deleuze asserts that a dispositif is:

[48] Ibid. p. 159.

> a tangle, a multilinear ensemble. It is composed of lines, each having a different nature. And the lines in the apparatus do not outline or surround systems which are each homogeneous in their own right, object, subject, language, and so on, but follow directions, trace balances which are always off balance, now drawing together and then distancing themselves from one another. Each line is broken and subject to changes in direction, bifurcating and forked, and subject to drifting. Visible objects, affirmations which can be formulated, forces exercised and subjects in position are like vectors and tensors.[49]

[49] Ibid.

Deleuze identifies four characteristics of Foucault's dispositif. First, it consists of curves of visibility and enunciation. The curves of visibility make forms or shapes of a given dispositif appear and disappear, and those forms are in fact the very constituents of the dispositif. By connecting the visibility to light and gaze, the disciplines such as paintings and architecture rely on the appearance and disappearance of forms in light and seeing. Second, the curves of enunciations (or affirmations, statements, etc.), based on the visible, hold together or transgress the boundaries of dispositifs by distributing the variables or the elements that form the "regime" of enunciations. The third is "the lines of forces." Deleuze describes the lines as vectors that indicate the directionality of forces and movement. The vectors travel from one point to another and traverse through different element within the dispositif. The vectors exemplify the "space" of the dispositif, and form the dimension of power. They are internal to the dispositif. In this case, the intersections of the vectors can be said of as a clash, a conflict, or a "battle." The fourth, from the previous three characteristics, subjectification takes place. Therefore, Foucault's dispositifs are composed of "… lines of visibility and enunciation, lines of force, lines of subjectification, lines of splitting, breakage, fracture, all of which criss-cross and mingle together, some lines reproducing or giving rise to others, by means of variations or even changes in the way they are grouped."

As a consequence, Deleuze first repudiates the notion of the universal, as the dispositifs comprise constantly variable and fluctuating lines of interests and objectives. They lead to aesthetic criteria that rely on the immanent qualities, rather than the so-called transcendental, according to the potentialities inherent in the matrix of lines of a given dispositif. Second, such a dispositif-construct negates the possibility of unchanging truth, and instead places a crucial importance on perpetuating the new. The newness does not indicate individual aggregate elements, but a collective regime arising from the intersecting and bifurcating lines of enunciations. Thus the new regime provides new contents and with them a new set of creative potentialities. Such new creativity – I will qualify it as *configurational* – also provides the ability to transform the dispositif itself.

In regard to configurational creativity, it would be useful here to mention the rhizomatic configuration of Deleuze and Guattari discuss in contrast to Foucault's dispositif. With the concept of rhizomatic configuration, in order to create links between the heterogeneous:

> Collective assemblages of enunciation function directly within machinic assemblages; it is not impossible to make a radical break between regimes of signs and their objects. Even when linguistics claims to confine itself to what is explicit and to make no presuppositions about language, it is still in the sphere of a discourse implying particular modes of assemblage and types of social power.[50]

[50] Giles Deleuze and Felix Guattari, trans. Brian Massumi, *A Thousand Plateaus*, Minneapolis: University of Minnesota Press, 1987. p. 7 (Introduction: Rhizome).

The common ground for creative potentialities results from the concepts that bind together various heterogeneous entities, even though the strategic functions of Foucault's dispositif on the one hand. The rhizome of Deleuze and Guattari on the other hand functions in an opposite manner. Foucault's dispositif indicates the kind of superstructure that binds and subjectifies the aggregate elements under an all-seeing gaze in a totalizing effect. The rhizome on the contrary provides fluidity and openness resistant to totalizing.

Surface Dispositifs: Enclosure as Techné

In 1966, a year before Foucault's lecture *"Of Other Space,"* Robert Venturi published *Complexity and Contradiction in Architecture.* Throughout the history of architecture, Venturi contends, architectural façades have been conceived and used as medium to communicate ideas and narratives by means of material, tectonic making, such as stone carvings, mosaics and fresco murals.[51] I would add that the building façades provide the basis of conceiving architecture as a dispositif that exercises the power to signify, symbolize, and communicate narratives, messages, and information specific to a given context of the dominant power and its agendas. In Las Vegas, for instance, Venturi finds architecture that augments and reinforces the dispositifs, in this case, of gambling and hedonistic pleasure. In Las Vegas architecture project fantasy, desire, and therefore subjectify, just in the same manner as those of "the basic cinematic apparatus" Baudry analyzed.[52] In this case for the age of automobiles, the images are static and the spectators are moving. Nonetheless, the spectators are just as immobilized as those in cinema, fixated on the images that are projected to them.

[51] Robert Venturi and Denise Scott Brown, *Architecture as Signs and Systems For a Mannerist Time*, Cambridge: Harvard University Press, 2004. pp. 24-25.

[52] Jean-Louis Baudry, "Ideological Effects of the Basic Cinematographic Apparatus" in *Narratives, Apparatus, Ideology: A Film Theory Reader*, ed. Philip Rosen, New York: Columbia University Press, 1986. pp. 286-298.

In regard to architectural design in general and to architectural façades in particular, the Venturi describes a model of augmented architecture. As Lev Manovich puts it, "... virtual layers of contextual information will overlay the built space."[53] Examples of augmented architecture range from the ancient Egyptian temples inscribed with hieroglyphs, the marble reliefs of ancient Greek temples, and the fresco murals of Pompeii, to the electronic display screens consuming architecture in Las Vegas casinos, the Ginza district in Tokyo, and Times Square, New York. However, as Manovich also points out, the concept of augmentation in terms of flat display screens is still based on the historical model of the cinematic apparatus and therefore hardly serves a purpose beyond the purpose of decoration and superficial affectation.[54]

[53] Lev Manovich, "The poetics of urban media surfaces." *First Monday*, No. 4 (2006): 1-13. p. 3. http://frodo.lib.uic.edu/ojsjournals/index.php/fm/article/view/1545. (Accessed 3 Feb. 2012)

[54] Ibid. p. 9.

When we surpass the flat display screen model of augmented architecture, digital architecture as a new form of techné, and therefore as a new form of a worldmaking strategy, can be illustrated. The rapid development and proliferation of digital intermodal apparatuses have accelerated product life-cycles, more frequent technological revisions, and higher efficiency in design and manufacturing. The virtualization by software applications offers a wide range of possibilities for simulation and analysis. Such applications help optimize the performance of the apparatus for living in, to revise Le Corbusier. They allow not only for the augmentation by the flat screen functioning as a part of the building's enclosure system, but also for the design-performance relationship to be simulated, visualized, and analyzed.

In contrast to the semiosis-augmentation model, the biological or autogenic model provides an example that is characterized by the synthesis of material, functional and structural configuration. This model is based on the organic and vitalistic propositions of self-emergence and attempts to converge material, form, and efficiency found in nature. The so-called biological-generative model concurs with the particular worldview that the work of nature is beautiful because each entity in nature, both living and non-living, is created in an appropriate place and manner according to the immutable laws of nature with its innate capacity for change and transformation. It regards the self-emergent nature as an appropriate model of material, configuration, and constitution for architecture. The self-emergent, natural entities are beautiful, durable and strong, highly efficient, and yet ecologically appropriate. They provide highly evolved models for a wide range of flexible and adaptable potentials. Thus, considering the two threads in parallel, the virtual and biological are regarded to offer the possibility of the kind of techné that will help us arrive at a new level of intensity in technological and morpho-tectonic sophistication. Above all, the conflation provides a coherent ideological construct that is centered on disclosing the substance of the relations with nature.

The virtual, generative, and biological models are drawn together – in an algorithmic-biosemiotic conflation so to speak – into architecture in order to incorporate the processes of selection, adaptation, optimization, and evolution. The biomimetic model, in particular, as simulated in the virtual, attempts to abstract the principles that lie behind a species capability of sustaining itself adapting and evolving its physiological composition in relation to a particular habitat over time. This model proposes that architecture is analogous to a biological organism and organization. For example, a building may incorporate skin that responds to environmental conditions. In this instance, the architectural enclosure should comprise an assemblage of dermal layers. Each dermal layer corresponds to a particular environmental criterion, and is optimized by a virtual process analogous to natural selection and evolution.

The primary strategy of the biomimetic model aims to devise a certain degree of sensitivity, automaticity, and adaptability in the function as well as the aesthetics of the architectural design. The various design parameters should contribute to the relationship between a building and its environment, both natural and artificial, in a highly optimized and refined manner. At the same time, the notion of self-emergent and self-generative systems, and the view of the world such systems help construct also point to the self-stabilizing and self-regulating configuration of man-made environmental entities that graft together the material and structural efficiency, formal expressiveness, and environmental adaptability in one seamless indivisible body.

Architectural enclosures and façades can be hypothesized in terms of surface. The first relevant conception for this is what the analytical philosopher Avrum Stroll describes as the "Leonardo surface."[55] Stroll posits that a surface is not a material entity but an abstraction, which not only separates but also connects two different entities or states, such as air and water. Surface as an abstraction is also an interface. It is a shared boundary with no "divisible bulk" that marks the theoretical differentiation among various substances and attributes.[56] Along this conceptual line, architectural façades can be thought of as a surface that belongs to both the interior and the exterior, and therefore, as that which not only demarcates but also conjoins the building and its exterior environment together inseparably. In addition, the architectural enclosure is indexical of the dynamic conditions where the interaction of the building and its environment is manifest in the resolution of the surface. In this sense, we can conceive of an architectural enclosure that not only possesses certain materiality but also, and more importantly, embodies the dynamic exchanges between the interior and the exterior.

Conceived as the surface of augmentation, the architectural enclosure not only reflects the external variations through its materiality and use of local resources but also projects its internal conditions through the use of images and patterns; we can conceive of an enclosure that in essence promotes a certain kind of equilibrium through mediation and interface. With images and patterns on the façades of the enclosure, the augmented architecture becomes expressive of the underlying

[55] Avrum Stroll, *Surfaces* Minneapolis: University of Minnesota Press, 1988. pp. 40-46. Stroll mentions that it is termed after Leonardo Da Vinci's description of surface in his notebooks.

[56] Ibid.

narratives or conventions – ideological, political, social or cultural – of its context. In this way, the dynamic conditions that surround a building become embodied in the mediated architectural enclosure.

In addition, Gilles Deleuze's *fold* and *coil* (*pli* and *repli*, respectively)[57] also provide a useful approach. They help construct the relation between the interior and the exterior by describing the façade as an active agent. Not unlike the Leonardo surface of Stroll, the process of folding and unfolding articulates the connective tissue of two states: interior-exterior, object-environment, media-substance, and so on. The architectural enclosure simultaneously connects and separates. They are permeable and impervious; constant and fluctuating. The architectural enclosure as surface-fold mediates two poles in a smooth and continuous transition. We can also speculate on what an ecology of techné, of establishing a relationship with the world, may mean for understanding architecture as mediative surface. Gibson's theory of visual perception indicates ecology as the way we perceive the composition of the world around us, simply put, the techné of perceptions. The human perception-world consists of surfaces that divide and join substances and attributes and allow us to find our place and, to borrow from Heidegger, to dwell. We can conceive of an ecology of being and dwelling as comprised of the invariants.[58] They help us locate our place in the physical environment as well as of an ecology. The invariants help us relate to and connect with the more intangible senses of meaning and purpose, the affordances.

[57] Giles Deleuze, "The Fold" trans. Jonathan Strauss in *Yale French Studies*, No. 80, *Baroque Topographies: Literature/History/Philosophy* (1991), pp. 227-247; in regard to the translation of "pli" and "repli" into fold and coil, see the translator's note, p. 227.

[58] James J. Gibson, *The Ecological Approach to Visual Perception*, New York: Houghton Mifflin Company, 1979, pp. 72-87; Gibson's *ecology* consists of *invariants*, those that provide constant reference such as the horizon or the regularity of the paving pattern of a sidewalk, and *affordances*, our understanding and recognition as to what we can do with objects in an environment.

Drawing from the discussions of the bio-generative model of architecture, it would be appropriate to consider the concept of mimesis. One of the fundamental problems inherent in the current consideration of mimesis and the mimetic is that the terms often refer to mimicking, imitating, and emulating certain organisms and/or natural conditions in a human-centric way, in order to satisfy our needs, pleasure, and comfort. When applied to architecture, this position misleads and distorts the more fundamental issues arising from the performance-critical criteria. More consequently, such a position reinforces the status quo of the human-centric view of worldmaking and subjugates nature as the standing reserve as Heidegger argues in Ge-stell. Such an approach focuses on solving or correcting immediate problems we have caused, as well as on providing sensory excesses through often manipulative affect systems. However, in the end, the lack of critical architectural discourse in regard to techné and technology results in the myopic fetishization on how usefully (and profitably) such bio-technological generative models serve our immediate desires, without addressing the fundamental cause of our problems stemming from our unsustainable approach to worldmaking. The situation may be likened to the pathology of human body: instead of confronting the underlying causes of symptoms, the failing organs of the body are augmented and replaced, and the atrophying body is propped up and made to function by the mechanical apparatuses. The substance of our relationship to natural organisms and environments is at stake, not the usefulness or affectation of such technological organs installed in order to satisfy our excesses and to reinforce our dysfunctional so-called lifestyle. This is not unlike what Slavoj Žižek describes as "The ultimate perverse vision" of the human body as a collection of organs "as in those unique utopian moments of hard-core pornography" (e.g. the close-up shots of a smoothly shaved vagina or penis, a bleached anus, perfectly formed breasts, etc.), in which the body is "thus transformed into a multitude of 'organs without a body,' machines of *jouissance*..."[59]

[59] Slavoj Žižek, *Organs without Bodies: Deleuze and Consequences*, London: Routledge, 2004. pp. 172-173.

Walter Benjamin proposes mimesis as a process that generates empathetic similarity in sensuous (e.g. literal mimicking) and non-sensuous (e.g. writing) categories[60] that both recognize and produce similarities. According to Benjamin, mimesis consists of both recognizing and producing similarities. It is a capacity for connecting with the surrounding environment and entities. One discovers and registers similarities first without any particular motive or purpose, without subjective reasoning, *felt* through body thus in a sensuous way. The subject's body produces the similarity. Sensuous similarity is the kind of mimetic capacity that may be directly imitated, unmediated, by the human body. Non-sensuous similarity is the mediated kind, or indicates no material physical entity that is to be related to, but by speculation through signification. This type of non-sensuous similarity is produced by an agency such as language, painting, music, dance, architecture, and so forth. Non-sensuous similarity may be produced without the actual object from which mimesis arises. In Benjamin's conception of mimesis, we also find environmental affinity and

[60] Walter Benjamin, "On the Mimetic Faculty" in *Reflections: Essays, Aphorisms, Autobiographical Writings*, ed. Peter Demetz, New York: Schocken Books, 1978. pp. 333-336.

empathy that "dissolve the contours of the subject/object dichotomy into reciprocity and the possibility of reconciliation"[61] rather than subjugation and exploitation. In Benjamin's conception of mimesis, we learn that the surface condition is not mediated by signification but by indexical commitment in which the relations of poiesis are registered materially. Given the sensuous nature of mimetic empathy, for Benjamin, the mechanical reproducibility and the ensuing loss of aura demonstrate a declining mimetic capacity, and the loss of affinity.

[61] Miriam Hansen, "Benjamin, Cinema and Experience: The Blue Flower in the Land of Technology" *New German Critique*, No. 40, *Special Issue on Weimar Film Theory* (Winter, 1987) pp. 179-224 (195).

At the same time the surface enacts the play between an entity and its affinity to a given environment. Being biomimetic does not mean imitating and transposing biological organisms and the way they adapt to an environment and its changing conditions. Neither is it about imitating the ways of natural organisms in an attempt to cover up the problems that are symptomatic of our conflict with nature. Instead, it is about how we situate ourselves and establish an intimate relationship with the biological world. Removed from this relationship, biomimetics will be nothing but a perpetual reiteration and versioning of copies' copies in an attempt to solve our problems, to satisfy our desires, and to embellish our unsustainable worldmaking.

Techné of/as worldmaking should be founded on the question of how we relate ourselves and our artificial world to the network of relations in nature and the natural world. However, the current motivation behind the bio-technological impetus appears to be intent on how to fix our problems or on how to make our life more convenient and entertaining by fetishizing the organs without the body. This stems from our lack of a meaningful relationship with nature and only reinforces the view of how the natural world can serve us and be exploited in order to maintain and continue ad absurdum the patterns of our excesses and waste that result in violence.

In common with the aesthetic evaluation of architecture lies the assessment of geometric harmony, proportion, symmetry, and order with respect to the prevailing worldview. Composition based on such an aesthetic order has been applied and practiced for millennia in order to impart properties such as beauty, grandeur, and power in everyday objects, buildings, and cities, in other words, in human-built ecologies.

Techné as worldmaking employs composition of surface through which the artificial world is interfaced with natural. The surface-enclosure provides the means by which we situate and establish our relationships, mimicking and enacting our presence in terms of our view and understanding of nature. But how important are the aesthetic qualities of techné in the design of surface-interface? How such aestheticized worldmaking is maintained and sustainable in relation to nature? For that matter, can we really discuss human-built ecologies in aesthetics terms? In this case, isn't aesthetics in fact a network of relations and of finding the appropriate position for our built environment within such a network? Indeed, central to architecture as a form of techné and worldmaking is the question: How do we conceive of the enclosure in relation to both our necessity to create interiority and the ecologies to which such interiority should relate?

In contrast to the surface of architecture that intervenes primarily a barrier, the foregoing questions implicate a perspective that enclosure as techné mediates the interior and the exterior, the human *Umwelt*[62] and nature. Such enclosure indexes not only the built environment's form and contents, but also the fluctuating relationship between the building and its environment. In nature, we indeed find unique examples that deal with problems akin to those architecture and human-built environment face in relation to nature. The approach that is directed at emulating natural attributes in terms of the utility that serves the anthropocentric worldview falls short of the potentials of surface both to mediate and to embody. The concept of the architectural enclosure as Umwelt-surface attuned to nature, in both the abstract and physical sense, foresees that it serves as both an agent of equilibrium between the interior and the exterior, and an apparatus within which certain mediative relations are imbedded.

The superficialization of the architectural enclosure that is purely visual and the optical results in the skin-organ without the body. The skin-organ turns perverse as well as hypocritical and fallacious. We can also criticize the fetishization of so-called interactivity in architecture. In this instance, the enclosure serves as an extension of an architecture that is driven by the novelty of effects that is quickly exhausted. Both of these tendencies in the design of architecture miss the point: the superficialization of architectural enclosures simply covers up an increasingly

[62] I employ the word "Umwelt" in the species- and/or subject-specific sense according to Jakob von Uexküll. See Jakob von Uexküll, *A Foray into the Worlds of Animals and Humans*, trans. Joseph D. O'Neil, Minneapolis: University of Minnesota Press, 2010. Kindle edition. In German, both Umgebung and Umwelt indicate "environment." The distinction between Umgebung (what is simply given [*geben*] around [*um-*] us, regardless of whether or not we relate to it, i.e. neutral, non-subject-specific) and Umwelt (the world [*Welt*] around [*um-*] us about which we cogitate, and to which we relate in some capacity, i.e. subject-specific) proves crucial in usage and conception. Unlike Umgebung, the Umwelt is distinguished by the elements that are particularly meaningful for the given subject, an animal species. Therefore, an Umwelt is a world that the subject and its biologically motivated interests define. There are as many Umwelten as there are animal species. Seen this way, the idea of "nature" appears untenable as we are simply one of those entities that is biologically and subjectively motivated.

excessive, obese body, while the mechanization of buildings and architectural enclosures fetishizes "the desubjectivized multitude of partial objects"[63] in the form of spurious mimesis and misdirected interactivity. If we return to the construct of surface as mediation between matter and affectation, architecture as techné is in essence the unfolding of various relations and forces between artificial constructs and their environment. This unfolding provides not only the aesthetic qualities but also an approach to the environmental conditions that ultimately dictate the terms of human habitat. This point of view suggests the kinds of tapestries that display narrative, structural, material, and environmental qualities, while serving the purpose of architectural construct as the surface of mediation, indivisible in their composition.

[63] Slavoj Žižek, *Organs without Bodies: Deleuze and Consequences*, London: Routledge, 2004. p.173.

The conception of surface in this sense presents the structure, the architectural enclosure and the façades that are interwoven. The role of the architectural enclosure is no longer arbitrary. The weaving and pleating that takes place in order to create the enclosure is carried out in the context of a certain technical maturity, where the environmental variables of a given site are addressed, and where the aesthetic qualities are inherently imbedded. The kind of performance and expression that is achieved is not simply superficial and passive. The techné of surface is blended with the very essence of architecture in a way that radically departs from the architectural enclosure that is seen as an additive, supplemental drapery.

Articulation of surface provides architecture a means of sublating the disparate views of the interior-exterior relationship with one that helps weave, pleat and mediate a series of environmental forces. With today's digital technology and virtual capability, and with new construction techniques and new materials, the construct of surface becomes the architectural design process itself. The surface, seen in this light, not only provides a membrane of communication and exchange, non-verbal but sensuous, but also embodies the quintessential qualities of human space that exist in intimate relation to the natural environment.

Experiencing the World: Wearable Technology and the *Umwelt*

Laura Beloff

The concept of biosemiotics proposes that each living organism's physiological abilities and biological needs form the base for its subjective perception of the world. This particular perception was originated by Jakob von Uexküll (1864-1944) and is known as the *Umwelt*. According to this viewpoint, the world is full of interconnecting and overlapping spheres—like a conglomeration of bubbles forming multiple perspectives in which each organism has its own *Umwelt*. Hence, the human perspective is just one among many perspectives of the world.

The concept of *Umwelt* is tightly linked to the notion of survival, and that each organism includes within its *Umwelt* what is necessary and essential for its biological survival. The idea of survival, which is guided by biological evolution, concerns the existence of biologically natural organisms. The author is concerned with the currents of human evolution, as such notions relate to self-conducted design alternatives for the human body, which often no longer follow survival as their primary guide, but are motivated by a different goal. The chapter perceives wearable technology projects as an area for imagining and experimenting with human enhancement. In other words, wearable technology is not perceived as an isolated technological development, but is profoundly dependent on the human and constructing on existing human faculties. In this chapter wearable devices are considered as newly designed human faculties that affect the subjectively formed individual *Umwelt* through their intimate connection to the body. The text focuses specifically on wearable technology projects, which are networked and, in a sense, construct new kinds of connections for a human body via technology. These projects that are emerging from the field of the arts, differ clearly from developments that are driven, for example, by market and commercial interests. Instead of considering wearable technology devices as tools that aim to aid and enhance the human body, the author investigates how wearable technology impacts on our perception of the world. To realise this aim, the human is seen as a construct of a multiplicity of relations, such as the interconnected bubbles of subjective perceptions that exist within a matrix of heterogeneous elements, and evolve into an entity, at once enhanced by technological, wearable devices.

In order to explicate the theoretical formulation of the aforementioned aim, the text presents the author's wearable technology artworks. These works are the result of an investigatory process that focuses on the human and her evolving relation to the surrounding world.

1. Introduction

Pacemakers, artificial organs, some prosthesis, and even contact lenses are all examples of artificial and technological body enhancements developed within the medical sciences, which function involuntarily without the conscious control of the wearer. In these instances, the technology becomes an integrated and, to some extent, invisible part of the human, the wearer's body and his world. The usual reason for the implementation of such artificial enhancements of embedded technologies is to repair or return a body to its expected functioning state, which is based on an ideology about what constitutes a *normal body*. In other words, if the body is considered to be incomplete or in the need of repair, then it needs to be returned to what is often considered to be equivalent to the expected functionality of a *normal* body.

The *normal* body is a concept that is tightly linked to one's cultural setting; different cultural values create a different understanding of *normality* and also influence the degree of acceptance of body enhancements. Body enhancement and body modification practices present "a manifestation of changing ways of thinking about biological and social life that is fundamentally transforming institutions, economies, and meanings"[1]. Thus, one could say that the typical approach of Western medical science is to *repair* the body, whereas the idea of *upgrading* the body is beyond this scope.

[1] Hogle, Linda F. "Enhancement Technologies and the Body." *Annual Review of Anthropology* 34 (2005): 695-716. Print.

Aimee Mullins is an exceptional example of somebody who is revealing our slowly evolving attitudes concerning body enhancements. Mullins was born without fibula bones and had her legs amputated at a young age. Today her prosthetic legs are also fashion accessories, which she cheerfully changes, depending on her mood and the situation. Her collection of legs ranges from haute couture wooden legs created by fashion guru Alexander McQueen to transparent limbs used in Matthew

Barney's Cremaster Cycle movies and high-tech legs designed for running[2]. Mullins' case reveals that a playful approach towards body enhancement can be currently accepted only when a person with *real* physical abnormality is making use of it. In the current social and ethical climate it is possible to be playful with real physical body parts only within the framework of what is perceived as a *normal* body.

[2] http://www.aimeemullins.com/ [accessed 28.12.2013]

The field of wearable technology, which lies outside the medical sciences, is strongly connected to the idea of extending human ability. This field has developed with various distinct approaches and has informed by a variety of disciplines that are typically guided by their own developed framework and anticipated goals (e.g., from engineering and computer science, which typically treat portable or wearable technology as a tool that provides the user with extended and new abilities, such as telecommunication). Today the field of wearable technology has become more specialized with different strands of development emerging in the wide field, such as e-textiles, fashion and computing, smart materials, health-related technology, biometrics, quantified self initiative, and mobile device development in general.

The author is primarily concerned with approaches to wearable technology that are emerging within the arts field which often visibly differ from the aforementioned approaches. These wearable technology artworks can be considered express characteristics beyond the instrumental use of technology. In some way they resemble the body-embedded technology and its involuntary functions that are independent from the wearer's control. However, in comparison to the body-embedded technology for medical purposes, which typically focuses on the user's body and its functionality as an autonomous and independent entity, the wearable technology works that are emerging from artistic practice often concentrate on the perceptual connection between the wearer's body and the surrounding world. That is to say that even while these two approaches resemble each other (e.g., in their often automated and involuntary functionality) their focus point is different. To delineate, one approach concentrates on the body's inner abilities (e.g. with a use of a heart-pacer) and treats the body as an independent unit whereas the other focuses on the constant relation between the body and the outer world. (e.g. with mobile network technology applications). The author's interests are focused on the works with the latter approach and more specifically on works where the connection to the surrounding world is constructed through technological networks.

The chapter has two foundations: firstly, in relation to the author's artistic work it considers wearable technology as a newly constructed human faculty and it claims that the *wearability* of technology makes it more able to become a part of one's *Umwelt*. Secondly, the chapter considers the human and the world as a techno-organic entity, which includes organic and technological parts in conjunction. To clarify, the term *techno-organic* is used in this text in reference to: the merger between humans and technology, and the environment and technology.

2. *Umwelt*

Umwelt is a concept from biosemiotics, which was configured by the biologist Jakob von Uexküll (1864-1944). The term refers to a concept of the subjective world of an organism. The world can be imagined as a soap bubble that surrounds each individual and contains signifying markers relevant only to the world of that specific individual. This soap bubble, or *Umwelt*, is created by the individual organism in a process of forming a perception of reality, which is guided by the organism's design, physiology, and needs. Uexküll realised that every species has its own constructed *Umwelt* because each species reacts in a distinctive way to the same signals it receives from the physical world[3].

[3] Uexküll, Jakob von. "A Stroll through the Worlds of Animals and Men; a Picture Book of Invisible Worlds." *Instinctive Behavior; the Development of a Modern Concept.* Ed. Schiller, Claire H. New York: International Universities Press, Inc., 1934. 5-76. Print.

Uexküll's overall research ambition was to see meaning as the key concept of life. For him, life events could be explained as an interpretation of sign and meaning; a continuous dialogue between an interpreting subject and its *Umwelt* throughout its development and life (Jämsä 2008). According to Uexküll, the physiological design of an organism impacts its *Umwelt*. To prove his claim Uexküll performed a series of experiments with different organisms. For example, he demonstrated that a fighting fish does not recognise its own reflection if it is shown it eighteen times per second, but it does recognise it if it is shown at a speed of thirty times per second. The experiment proves that in the world of fighting fish, "who feed on fast-moving prey, all motor processes—as in the case of slow-motion photography—appear at reduced speed"[4]. This lead Uexküll to a conclusion, that the *Umwelt* of a fighting fish is based on its need to capture food for its very survival. In other words, the physiological abilities of a fighting fish has developed in relation to available nutrition in its environment, which affects its subjectively constructed perception of the world, its *Umwelt*. Uexküll clearly argues for a perception that an individual species and its environment are developing in tight connection, and this connection has a major impact on their evolution and survival. Uexküll's point of view was that biology should study organisms as active subjects of their environments, rather than as objects of an environment, and focus on an organism's abilities to integrate into varied and complex environments. Thus, biology should "deal with holistic units and to maintain a broader scope than physiology in order to grasp the interactive unity of the organism and the world sensed by it."[5] Uexküll was emphasising the fact that each individual organism is actively creating its own subjective *Umwelt*; what it includes into its perception of the surrounding world.

[4] Ibid: p. 28.

[5] Rüting, Torsten. "Jakob Von Uexküll: Theoretical Biology, Biocybernetics and Biosemiotics." Available at: www.math.uni-hamburg.de/home/rueting/UexECMTB.doc (2004). Print. [accessed 2.1.2014]

Human species has built a very complex world, and human evolution has always been both biological and cultural.[6] In comparison to Uexküll's perspective on organisms and their abilities for survival in a specific environment, the idea of physiological abilities of a human to survive seems to be a concern mainly when our biological survival is at stake (e.g. lack of nutrition or other basic biological needs). In the course of centuries humans have constructed a world based on our desires and needs, and, one could claim, largely parallel to the "wild" biological world. Our contemporary Western societies offer the means and social infrastructures (health care, food production, education, etc.) necessary for biological survival of humans. This situation has now enabled a different perspective on the evolution and development of physiological abilities of a human. We no longer need certain abilities or specified physiology as the prerequisites for biological survival are covered by constructed societal structures. However, we may now need different kinds of skills and abilities to be able to cope with the world we have built. The possibilities and potential for radical human modification and enhancement are opening up through developments in science & technology. This is also visible in the

[6] Taylor, Timothy. T*he Artificial Ape; How Technology Changed the Course of Human Evolution*. New York: Palgrave MacMillan, 2010. Print.

interest in wearable technology, which can be perceived as extension of biological human faculties. In a sense, we are ruling out parts of biological evolution of human species by gradually replacing it with design processes targeted to ourselves and our world.

3. Art, Wearable Technology, and Human Enhancement

In a similar way to Uexküll's research into the relationship between an organism and its environment in biology, art that is connected to real-life processes, such as participatory art, interactive art and also works of *wearable technology art*[7] amongst others, investigates the relationship between a human subject and the world. As an example, the author's wearable technology artwork the *Appendix*, 2011 (figure 1), is a networked tail designed and constructed for a human.[8] This technological device is designed to become part of the user's physiological body, but the tail's robotic movements are controlled and triggered by a natural phenomenon and by a human-constructed artificial system, which are external to the user. With this work, the author wanted to experiment with techno-organic connections that merge the user's body and the environment into a single entity.

[7] The term wearable technology art is coined by Susan E. Ryan. Ryan, Susan Elizabeth. "What Is Wearable Technology Art?" *Intelligent Agent* www.intelligentagent.com Eds. Ryan, Susan and Patrick Lichty. Vol. 8.1 2008. 7-12. Print.

[8] http://www.realitydisfunction.org/appendix/ [accessed 14.4.2015]

Conventionally, the *Appendix*-organ within the human body has been regarded as a redundant, potentially troublesome organ without any clear benefits. However, there are scientists who believe that the *Appendix*-organ is a site for beneficial bacteria to localize in, as a reserve for events of disorders caused by harmful bacteria.[9] This possible function is nevertheless still being debated, due to the fact that humans who have their *Appendix* removed appear to carry on their life without problems. The artwork *Appendix* is based on a similar notion of not having a clearly defined functional purpose. The constellation of the user and the *Appendix* tail is constructed for experimenting with a situation that challenges the perception on a human, her abilities and borders between a mobile body and its environment. This work experiments with technology that is designed with a non-purposeful and non-instrumental approach. The *Appendix* is based on artificially created (and, in some way, arbitrary) connections that are chosen with the intention of having no self-evident and easily interpretable meaning for the user. The horizontal direction of the tail movement is determined by the real time direction of the Helsinki

[9]http://www.abc.net.au/news/2007-10-10/scientists-discover-true-function-of-appendix-organ/693946 [accessed 8.5.2012], http://en.wikipedia.org/wiki/Vermiform_appendix [accessed 14.4.2015]

Figure 1. *Appendix*, photo by Laura Beloff, 2012

city transport tramway n:o 3 and the vertical movements are triggered by the close to real time wave height of the Baltic Sea. In the *Appendix* work technology provides the base for the created novel limb and faculty for a human. However, even if the core concept of the artwork is based on technology, it purposefully avoids an instrumental approach to technology as a means for achieving a predefined and purposeful goal. The *Appendix* is a constructed aesthetic experiment in which its benefits are largely and purposely unknown. The author perceives wearable technology as an area where experimentation with new and evolving human design is possible. It is an area where experiments in human enhancement have more freedom to be playful in comparison to body-embedded technology. This is due to the fact that wearable technology is external to the body, and therefore relatively quick and easy to put on and take off. However, this opportunity for playful and unconventional experimentation is currently primarily used by the practices emerging within art and design, which often drastically differs from the works motivated by technology, engineering or science. In artistic experiments the focus is often not on the purposeful functionality or on the usability of the device itself, but typically they address more conceptual and political questions.[10]

One approach of science driven development in wearable technology is found in the field of cognitive science. For example, a cognitive scientist Andy Clark has claimed that to become successful, technology needs to become intuitive and transparent in use, allowing it to become an intimate part of the user's cognitive abilities. According to him some technologies are more successful in becoming intuitive and subsequently invisible in use than others. He describes as *opaque* those technologies that require constant attention from a user and intervene with normal everyday activities. They require skills and capacities "that do not come naturally to the biological organism, and thus remains the focus of attention even during routine problem-solving activity."[11] Whereas Clark claims that intuitive, *transparent* technologies have the potential to become an extension of a man. This requires that the device feels natural for the user, which implies that the device is often designed to enhance the existing abilities of the user, but does not necessarily offer new capabilities. Clark argues that transparent technologies are so well integrated within our lives and

[10] There are few artists that have dealt with the topic of the physical body modification in their long-term practices, e.g. Stelarc, Orlan and Natasha Vita-More. They have investigated the aesthetic modifications of a body, and developed concepts on the future of human body. Whereas, the core of the author's works is in the creation of new kinds of connections between a human and his environment, which are constructed via (networked) technology. These works question what it means to be living within an increasingly techno-organic world.

[11] Clark, Andy. *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence*. New York: Oxford University Press, 2003. Print.

biological capacities that the devices become invisible in use.[12] In other words, according to Clark's definition, transparent technologies have the possibility to become a cognitive tool extending the abilities of a man, but opaque technologies have no real potential to become an extension of a man because they are not intuitively functional.

[12] Ibid.

Interesting is that, in comparison to Clark's statement, almost the opposite is evident in the field of the arts and speculative design, however, both approaches are part of the same development in wearable technology. The works and experiments emerging from the creative fields are typically not aiming at transparency and invisibility of technology, but rather quite the opposite. Instead of following the general aims of the wearable computing field[13], e.g. the above-mentioned transparency and intuitiveness, these projects appear to follow their own self-defined criteria. These works are not necessarily convenient to wear but may require physical (as well as mental) adaptation from their users. It is easy to see that playfulness is a common feature in the experimental approaches.

[13] Barfield, Woodrow, and Thomas Caudell. "Basic Concepts in Wearable Computers and Augmented Reality." *Fundamentals of Wearable Computers and Augmented Reality.* Eds. Barfield, Woodrow and Thomas Caudell: Lawrence Erlbaum Associates, Inc., 2001. 3-26. Print.

It is apparent that there exists a clear contradiction between the desired transparency and intuitiveness of technology, which according to Clark is the only way to make technology become part of one's cognitive ability[14], and the playful and strongly visible characteristics of the wearable technology artworks that clearly challenge this claim. In spite of this obvious contradiction, the author claims that these artistic productions come as a part of one's subjective *Umwelt* in a similar degree to the technological devices and tools that are specifically designed as seamless extensions of human ability. The difference is that these distinctive artworks are based on an intentional strategy, which is not aiming at confirming prevalent values and perceptions about the merger between human and technology, but aims to open up new perspectives and ideas about human potential and our future. For example, the absurdity and discrepancy, which are present in the aesthetics of the author's *Appendix*-tail and its purposeless connections between the user and the environment, opens up questions and potential scenarios rather than provides answers to existing problems.

[14] Clark 2003.

4. The techno-organic merger in the *Hybronaut*

The author has named the *Hybronaut*, a human figure that is essentially connected to a technological network, mainly through wearable technology device that visibly manifests this connection. The *Hybronaut* is a concept that was developed and is primarily used in connection to the author's wearable technology works. It has been previously articulated in detail by the author through various articles.[15] In summary, the *Hybronaut* was developed, at the time (around 2008-10), to be able to discuss and reference a user + a technological device as a single entity, instead of focusing onto the relation between a user and a technological device as two separate entities. The development of the *Hybronaut* concept enabled human enhancement questions to emerge as it enforced a shift of focus from the relation between a user and a technological device to the relation between a technologically enhanced user (a user + technology) and her environment. This relation in focus, between the *Hybronaut* and her environment, is grounded on the existence of technological networks. In other words, the *Hybronaut* is a techno-organic constellation and a figure, which can only exist in a world that is a complex structure of merged physical, technological and organic components. John Law has claimed that a person is an effect generated by a network of heterogeneous materials that are interacting.[16] The *Hybronaut* is based on a similar idea; the *Hybronaut* is established as a complex network of physical and virtual interactions, materials, humans, and organic and technological components all interacting simultaneously.

One of the earlier examples of the author's works is *Empty Space*, 2009 (figure 2), which investigated emotional side of human life.[17] The work investigated loss (and physical non-presence vs. presence) in a techno-organic, networked world. The work was grounded on an idea how humans and societies commonly express a loss and respect for it. The work is a constructed material monument that is networked and can be dedicated online to one's selected loss. It is created as a wearable and material artefact that is designed for commemoration - a contemporary memorial. The created wearable artefact is a transparent capsule, which is pumped empty inside creating a vacuum – an actual physical *Empty Space* in the world. On the side of the capsule is a small screen, which displays the dedications submitted online to the work. These dedications can be

[15] For example in: Beloff, Laura. "The Hybronaut Affair: an ménage of art, technology and science." In More, M. & Vita-More, N. (Eds) *Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future*. Wiley-Blackwell, 2013. 83-90. Print.

[16] Law, J. 2003 [1992], *Notes on the Theory of the Actor Network: Ordering, Startegy and Heterogeneity*. Available at: www.lancaster.ac.uk/sociology/research/.../papers/law-notes-on-ant.pdf. [accessed 2.1.2014]

[17] http://www.emptyspace.info/ [accessed 14.4.2015]

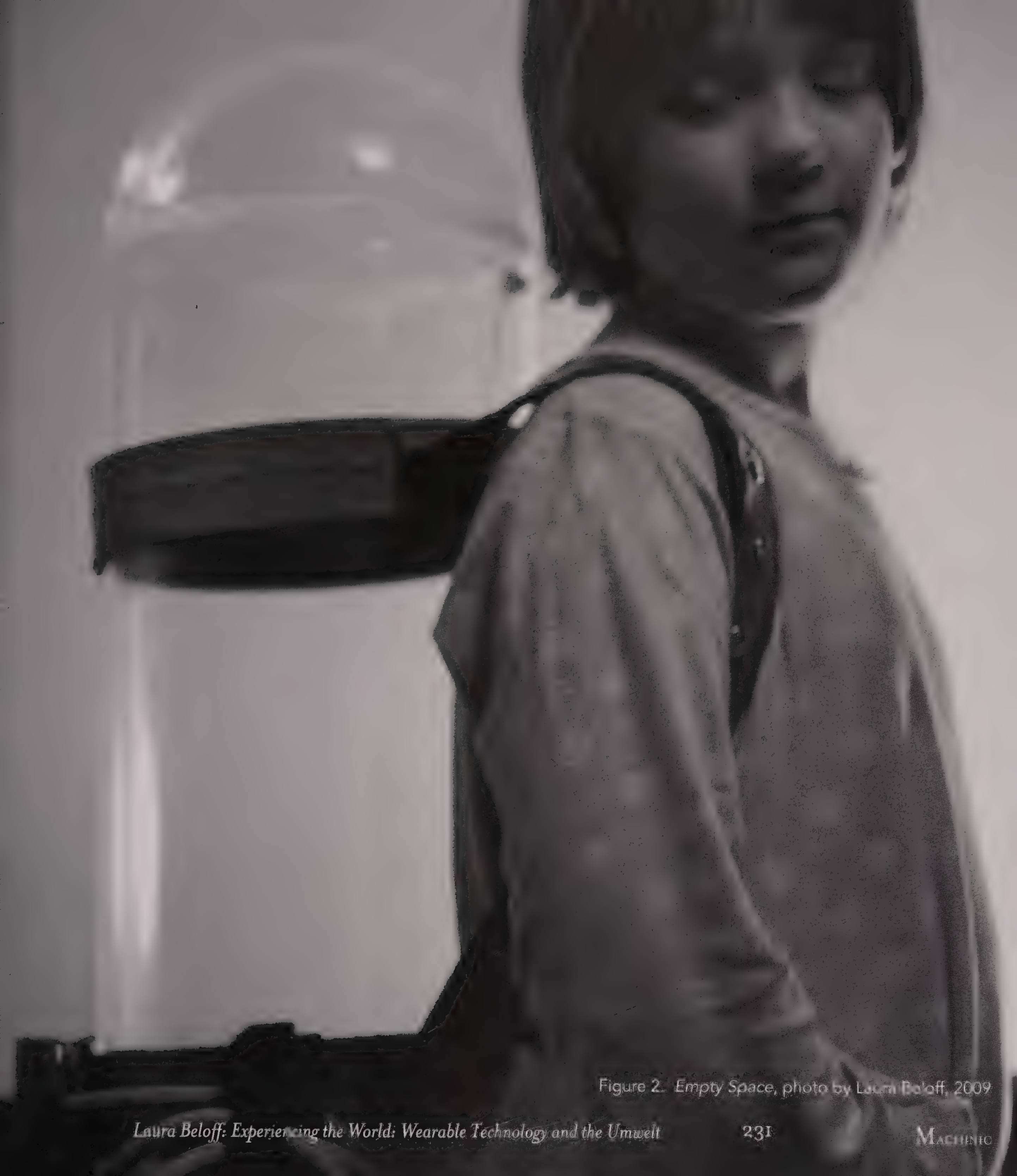


Figure 2. *Empty Space*, photo by Laura Beloff, 2009

set to a specific time of the year, the day, the hour and also the duration of the dedication can be set online. The short dedication text will be shown on the screen at a defined time. *Empty Space* is a mobile memorial sculpture for a public use, which offers an opportunity to dedicate the piece temporarily to one's personal use. An inherent feature of the *Empty Space* is mobility and its dependency on humans, as the memorial artefact travels on the back of someone. In a sense the work is designed as a wearable parasite, which uses the human as a vehicle to move from place to place. The users, or the voluntary carriers, of the *Empty Space* capsule become *Hybronaut*'s existing in a techno-organic world. The submitted personal dedications appear, not only publically on the physical world (on the screen), but they also enter the *Umwelt* of the *Hybronaut* carrying the artefact. The *Empty Space* work is a constellation of networked technology, physical material artefact, and biological organism (a human). It is an artefact that belongs to the realm of the techno-organic world.

One of the central aspects of Uexküll's *Umwelt* concept is an organism's ability to interpret visual signs via a process guided by the organism's physiological faculties and needs. According to Uexküll, the organism's subjective *Umwelt*, the perception of the world, is created on the basis of recognisable signs, in other words, what it is able to see or sense, which is subsequently guided by its physiological abilities.[18] Uexküll's viewpoint outlines an understanding of reality as perceiver-dependent, whereby what counts as a relevant world is inseparable from what is perceived.

[18] Uexküll, 1934.

The *Hybronaut*'s design includes a network faculty, which is a vital aspect of the constitution of the *Hybronaut*. Firstly, this faculty locates the *Hybronaut* within the techno-organic environment. Secondly, it is one of the core issues in the formation of his identity based on various relations within this environment. And thirdly, the *Hybronaut*'s subjective *Umwelt* always depends on what his biological and technological faculties allow him to perceive and sense. The merger of human and technological systems is an intrinsic feature of the *Hybronaut*, whose basic existence is dependent on these connections. In the case of the *Hybronaut* the survival at stake is not necessarily a biological one, but one related to connectedness via technology. The *Hybronaut* is enhanced for survival in this techno-organic environment that also forms her unique *Umwelt*.

The *Hybronaut* perceives and constructs the subjective *Umwelt* within the frame of her physical and cognitive abilities, which are extended, and sometimes also hindered, by the wearable equipment. In her world the lost network connection causes a loss of the subjectively constructed *Umwelt*, as well as a loss of existence as the *Hybronaut*. One can claim that in the case of the *Hybronaut*, the aim for survival, or *staying alive*, has been superseded by *staying online*.

The two previously described works by the author, the *Appendix* and the *Empty Space*, present playful experiments within an environment that has become essentially networked and founded on technology. These created artistic experiments aim to stretch the borders of techno-organic environment, and its development by addressing issues that commonly have no part in the market-driven or technology-focused research processes, such as emotionally anchored loss in human life, which is the topic of the *Empty Space*. Whereas the currently strengthening presence of techno-organic environment has evoked the creation of the *Appendix*, which is a work based on a combination of familiar and unfamiliar aspects. The familiar aspects we can easily relate to, e.g. how networks have become part of our identity and existence, and a tail as a limb, which humans have lost in the course of the evolution. The unfamiliar aspects are the use of 'random' network connections to our environment, which in this work become part of our existence through the tail and its movements. These connections, as well as the movements of the tail, are beyond the control of a user.

In these experiments the techno-organic environment enables the existence and survival of the *Hybronaut*, but only within the limits of this environment. Similarly, and in reference to Uexküll's ideas about the relation between organisms and their environment, in the biological world an organism survives and evolves in a reciprocal relationship within the limits of its environment and subjectively created species-specific *Umwelt*.

5. New agendas

The methods of manipulating our environment, which have been developed by humans, are also impacting on us as organisms of that environment. These methods include e.g. excavation of natural resources, construction of technological infrastructures, and cultivation of various organisms among various others. The recent decades have evidenced a development of more radical means of manipulation of biological matter than e.g. traditional cultivation methods used in agriculture for centuries. Today, the impacted changes are not merely adding onto the existing environment, such as e.g. hardware based network infrastructure, but are using bio-technology to modify existing biological organisms and organic matter in a cellular level, and creating novel organisms e.g. in the field of synthetic biology.[19] These novel methods of modification and creation of new organisms verge on the increasingly vague line between biology, technology and computer science. The merger of these distinct fields is becoming evermore obvious also in other areas than in the field of science and technology where it has been actively evolving. During the recent years these changes have received fair amount of critical attention among scientists and cultural theorists. Also the term *anthropocene* has become part of our common vocabulary with an agreed notion on humans' impact on the Earth's ecosystem.[20]

[19] http://www.jcvi.org/cms/press/press-releases/full-text/article/first-self-replicating-synthetic-bacterial-cell-constructed-by-j-craig-venter-institute-researcher/home/

[20] http://www.astrobio.net/interview/the-anthropocene-humankind-as-a-turning-point-for-earth/[accessed 18.4.2015]

In the author's *Hybronaut*-figure one can see a merger of an organism and networked technology. The author has also speculated with more complex formations of organisms and information technology in the three works described below; the *Fruit Fly Farm* (figure 3), *A Unit* (figure 4), and *A Bioreaktor* (figure 5). These works clearly propose that the romantic notion of *human-'wild'* nature relationship is changing, and potentially becoming obsolete. These works speculate on the following questions: When organisms are no longer emerging within environment but are in some degree designed and artificially constructed, and when humans are becoming increasingly enhanced species, and when the natural environment is no longer 'wild' but under human control: How is the emotional and experiential relation between humans and the so-called nature evolving? And, what kind of novel connections will form between an enhanced organism and an enhanced environment?

One of the earlier wearable works by the author, the *Fruit Fly Farm*, 2006, combines a wearable, technologically networked *Fruit Fly Farm* and a human as a single entity.[21] In this work, the human experiences

[21] http://www.realitydisfunction.org/ ; http://www.saunalahti.fi/~off/off/fruitflyfarm.htm [accessed 14.4.2015]

…e 3. *Fruit Fly Farm*, photo by Anu Akkanen 2006

Figure 4. *A Unit*, photo by Laura Beloff, 2012

Figure 5. *A Bioreaktor*, photo by Laura Beloff, 2014

a co-presence with biological organisms and with other people within techno-organic environment. The work forms a connection between the wide audience, the user of the work and non-human organisms, the fruit fly community through networked mobile technology. It is a hybrid construct where a user is not an isolated body, but an enhanced entity that is tightly connected to her techno-organic environment. The *Fruit Fly Farm* offers an immediate real-life experience in the context of the work, in which the user becomes a component in a newly formed techno-organic ecosystem. This work was developed at the time when mobile technologies had been adopted by the large public, but there was still little ideas what the phones could do except being a phone – a device for communication between humans and equipped with a low-quality camera.

Gregory Bateson has claimed that the unit of survival in the real biological world is the organism plus its environment.[22] This claim contains a conclusion that the organism that destroys its environment destroys itself. This viewpoint suggests a cohesive image of a synergistic organism, one that is firmly joined with its environment. This claim has been the starting point for a work *A Unit*, 2012. This work speculates on the potential beneficial impact on human well being by the green environment. The work was initiated by investigating the on-going scientific research on the green areas and their impact on human health.[23] The approach in this work differs from the other previously presented works, which investigate the technological environment and its relation to people. In this work the focus is on the natural environment. However, in a very similar sense to the author's previous works, where the virtual, technological environment has developed to become part of our physical and bodily existence through the proliferation of mobile devices and wireless networks, this work proposes a similar relationship between people and organic nature. The work *A Unit* consists of a human, the organism, and a piece of organic nature, a plant, which represents the environment. Instead of considering that the human would become immersed in a green organic environment, the work proposes the opposite; the environment is becoming mobile and a part of an individual's realm. The work is constructed as a miniature green area to be worn on the arm by an individual. It experiments with an idea of wearable miniature green space that

[22] Bateson, Gregory. "Pathologies of Epistemology." *Steps to an Ecology of Mind*. Ed. Bateson, Gregory. London, Toronto: Granada Publishing Limited, 1978 [1969]. 454-63. Print.

[23] The research in Helsinki University Centre for Environmental Research - HENVI conducted by Liisa Tyrväinen and Aino Hakala. The research is directed towards urban planners, architects and the health sector, having very practical use for the results. My approach and aim was not to produce scientifically valid results, nor discredit the value of scientific research, but to pose questions and experiment beyond the anticipated framework. Yet following the route marked by the scientific research.

becomes part of one's everyday existence and asks if this can be considered a natural green environment with potential health benefits.

The work *A Unit* has also another agenda that speculates on the formation of relations between a human and her environment, as both are being increasingly enhanced, modified and manipulated through technological means. *A Unit* is a wearable device that is specifically designed for a post-biological (largely human-constructed) plant, such as wheat that has been cultivated for centuries, or contemporary equivalent – gene-modified (GM) plant. In a way, even if this work does not have any hardware technology in its construction, it still addresses the technological enhancement of the environment on another level. One can perceive *A Unit* as exercise equipment for our changing relations with the environment, for the future when both humans and nature are largely artificial and constructed.

Progress in the field of science and technology, e.g. in synthetic biology or biophysics, indicate an increasing interest towards creation of novel hybrid entities; organisms, that are partly artificially constructed and partly biological. The aim may be e.g. a hybrid entity, which combines beneficial aspects from the both parties. For example, energy is one of the critical questions concerning artificial organisms, whereas biological organisms are able to produce energy for their own use. A control is an aspect that is easy to implement when organisms are artificially constructed, but not simple to implement when it concerns biological organisms. Similar types of ideas are also underlying the work *A Bioreaktor* by L. Beloff & M. M. Borch, 2014. *A Bioreaktor* is an experiment born in the intersection of art, design, biology and technology.[24] It is constructed as a symbiosis between a human and microbial fuel cell. In general, a microbial fuel cell is a bio-electrochemical system producing energy based on microbe interactions; in *A Bioreaktor* the microbial fuel cell is build as a closed system which contains microbes and algae that produces oxygen for the microbes to use. The initial starting point for the work was energy as one of the key questions of our future. *A Bioreaktor* is focused on the underlying perception about energy and life as a symbiosis within its surroundings. Following Salminen & Vaden's writing on energy and experience where they argue how impossible it is to think about energy as an object or material. Even if its effects

[24] http://www.realitydisfunction.org/?page_id=25 [accessed 14.4.2015]

are perceivable (or sensible), "energy seems to name at the same time something internal, immaterial and spiritual and something material, concrete, and physical."[25]

[25] Salminen, Antti & Vadén, Tere. *Energia Ja Kokemus.* Niin & Näin -Kirjat. Tampere: niin & näin, 2013. Print.

Microbial fuel cells have recently generated a lot of interest among the energy industry. Our modest experiment aims not to maximize the effectiveness of energy production, but rather to form questions such as: How small microbial fuel cell makes sense? What happens when you (a human) will become a life support system for the energy production unit? The work consists of a wearable microbial fuel cell, which requires a human as a necessary component for the flow of water within the system. In the current experiment the system produces digitized data about the current status of the living ecosystem. In a sense, the project challenges our perception concerning production and consumption of energy, and on the other sense the project explores concretely the formation of an ecosystem with dependencies, which consists of information technology, microorganisms and a human.

6. Conclusion

The chapter has investigated the increasing possibilities for technological enhancement of humans and environment. The author claims that an intentionally chosen tactic that is based on opaque technology, and which is visible in the described wearable art works by the author, functions as a disruption against the expected smooth integration of technology with a human and the world. The described experimental art works construct situations that are typically playful and may generate a certain amount of scepticism in the observers. Nevertheless they also show potential to reveal new insights into our, often very instrumental, perception of technology and our increasingly techno-organic world. Rather than focusing solely on purposeful extensions of human abilities, the presented artworks take a holistic approach and investigate the relation between a technologically enhanced human and an enhanced environment.

Further more, our terrestrial environment is increasingly constructed by humans, which no longer concerns merely the visible world-construction, but also molecular level manipulation of living organisms. It is obvious that the time when we perceived organisms as natural 'products' of their environment is over. Today the human-made new hybrid ecosystems support survival and emergence of the designed novel organisms, which may be combinations of biology and technology. These artistic experiments by the author are constructed as models, which provide opportunities to investigate and experience new kinds of constellations between biology and technology. As concrete and materially constructed situations they provide a mental space for users, in which it is possible to gradually adapt to new concepts, their potentialities and limitations.

Open Worlds: Bergson And Computational Ontology

Graham Wakefield

These are exciting times for worldmakers. Both fully immersive virtual realities, and mixed realities that blend with or augment the real, are proliferating. This path to worldmaking is suddenly widely backed and affordable, with eager anticipation far beyond the recently catalyzing space of videogame virtual reality. After decades-long gestation this medium bears the hallmarks of birth. However its unique messages remain to be deciphered, its conventions and genres to congeal, and the inevitable McLuhanian rear-view awkwardly projects the well-worn tropes of videogames, and struggles with the loss of the frame, the cut, and the directed passivity of cinema. Rather than extrapolating forward from the familiar in this way, as worldmakers we venture to a more speculative goal: a creative ontology consummating the vast creative poiesis that the generative grain of computation makes possible, making worlds that approach the open-endedness of the natural reality we inhabit, including its endless capacity to change and reveal surprisingly new and fascinating phenomena. To illuminate a way forward, this chapter revives the nature-inspired creative philosophy of Henri Bergson, and addresses the challenges and potentials of re-projecting it into interactive computational media.

Generative ontologies

The virtual worlds of many videogames already create the desirable illusion of a vast space rich with possibilities, however all too quickly we discover boundaries are closer than they appeared, actions and responses are few, and discoveries are pre-scripted. The more that worlds surround our senses, the more these limitations work counter to the transportation of presence, the sense of *being there*. When we cannot reasonably pre-author every detail of a world we increasingly turn to algorithms to provide the consistencies and features of a world, and the more a world derives its meaningful values from the generative capacity of algorithms, the more actions and responses can have unforeseen yet persistent consequences leading to emergent experience.[1] To this extent worldmaking becomes process-oriented ontology expressed in the creation of software.[2] Artists exploring the capacity of generative algorithms to present emergent modes of being-in-time are frequently attracted to the apparent open-endedness of complex systems such as agent-based flocking

[1] Where artists use the terms *generative* and *algorithmic*, game developers tend to use *procedural* and *simulation*. We note that headline-grabbing company Improbable have dubbed "strong simulation" as the way forward for a game industry hitting the scalability limits of pre-scripted content–and it is no accident that Improbable's working sample is a simulated ecosystem (http://improbable.io, accessed May 2015).

[2] In this chapter we use the term *ontology* with its millennia-old meaning–the philosophical reflection upon what exists–rather than its more recent usage in knowledge engineering. In the latter case it defines the categories and hierarchical structure of information for a given system, such as the schema of a database, which, as we shall show, reflects an implicit Platonism incompatible with the creative organizations we seek.

models or reaction-diffusion automata. Such models are easy to encode in software and show a ready capacity to generate new patterns and emergent behaviours. However, there is a risk in simply importing models that were largely invented for the purposes of more accurately predicting or representing isolated fragments of the physical world-*as-we-know-it*: despite the bottom-up, emergent character of the algorithms themselves, they originate from pre-written, top-down goals, and accordingly may confine us to worlds of more limited creative and reflective potential:

> The underlying systems themselves are crystalline and impervious, and this character underpins our experience of these works... Entities are identical, or belong to a set of pre-defined types, and their properties and behaviour are static over time. The systems have a particular relation to time: they tend to be a series of instantaneous slices… history is all but absent… The environment here is (literally) a blank canvas, inert, empty space… [the agent is] a clone in a crowd, unchanging, with no traction on the space it inhabits, existing in an ongoing, perpetual present.[3]

[3] Whitelaw, M. *System stories and model worlds: A critical approach to generative art*. README, vol. 100, pp. 135–154, 2005.

The impoverished nature of the models identified by Whitelaw above echo remarkably criticisms made by the philosopher Henri Bergson a century earlier. Bergson denounced models of living organisms in which "we represent statically ready-made material particles juxtaposed to one another, and also statically, an external cause which plasters upon them a skillfully contrived organization". And similarly that "by combining together the most simple results of evolution, you may imitate well or ill the most complex effects; but of neither the simple nor the complex will you have retraced the genesis, and the addition of evolved to evolved will bear no resemblance whatsoever to the movement of evolution."[4] There is even a passage of *L'Evolution Créatrice* in which Bergson anticipates kinds of procedural animation used widely today–suggesting throwing onto the screen a large number of jointed figures animated according to models of marching, varying from individual to individual. However Bergson asks, even though "we should need to spend on this game an enormous amount of work… how could it reproduce the suppleness and variety of life?"[5]

[4] Bergson, H. *L'Evolution Créatrice*. 1907. (Henri Bergson, Creative Evolution, tr. Arthur Mitchell, Henry Holt and Company, 1911)

[5] Bergson, 1907.

In response, in this chapter we reappraise Bergson's ideas through a computational medium, to ask whether the static and contrived qualities

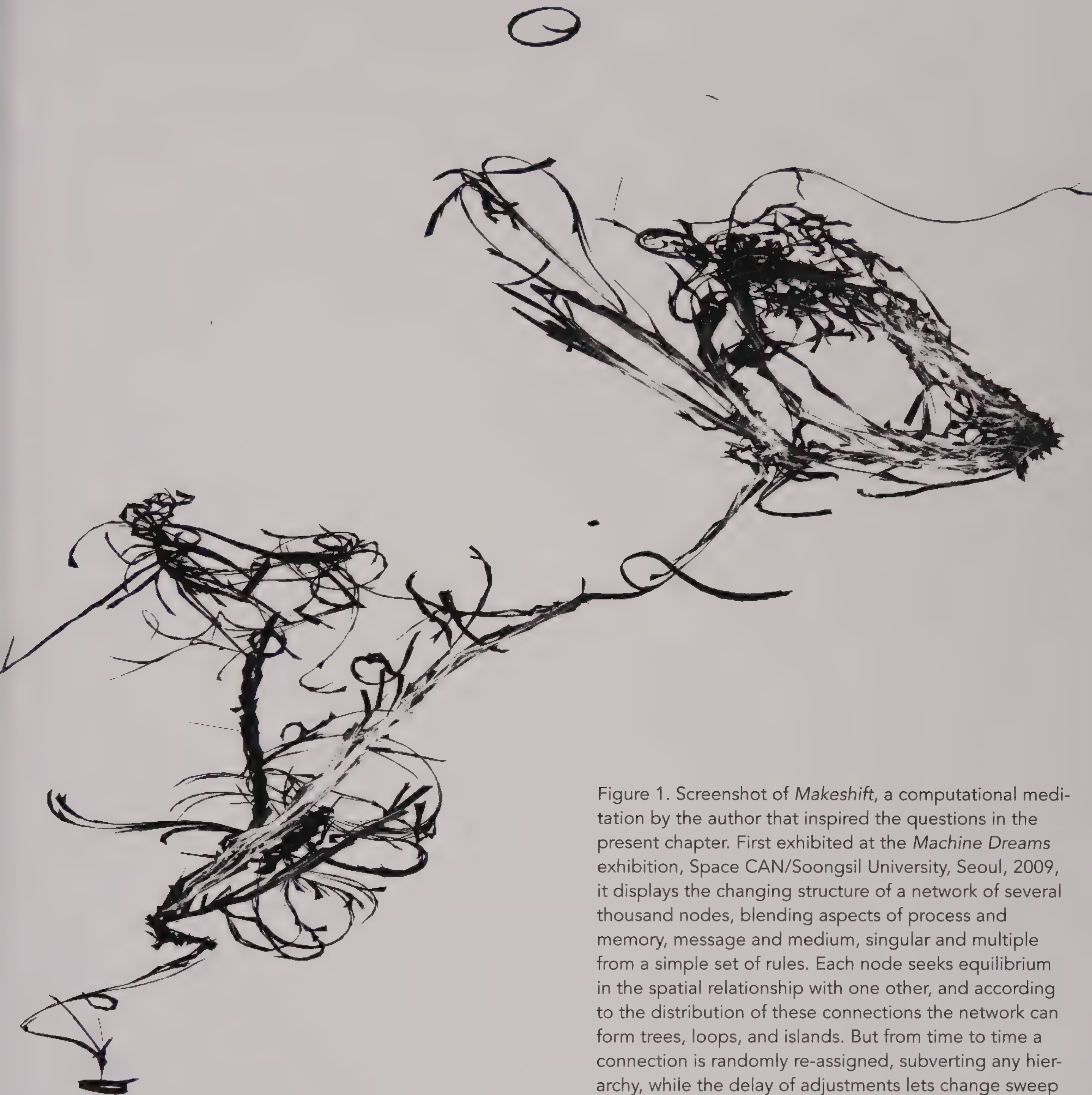


Figure 1. Screenshot of *Makeshift*, a computational meditation by the author that inspired the questions in the present chapter. First exhibited at the *Machine Dreams* exhibition, Space CAN/Soongsil University, Seoul, 2009, it displays the changing structure of a network of several thousand nodes, blending aspects of process and memory, message and medium, singular and multiple from a simple set of rules. Each node seeks equilibrium in the spatial relationship with one other, and according to the distribution of these connections the network can form trees, loops, and islands. But from time to time a connection is randomly re-assigned, subverting any hierarchy, while the delay of adjustments lets change sweep through long tails, and local rotations spread to the whole. https://vimeo.com/161162336.

Figure 2. Flying pelican captured as a chronophotograph by scientist Étienne-Jules Marey around 1882. Bergson and Marey were colleagues at the College of France in 1902. Image reproduced with permission of Wikimedia Commons.

identified in these quotations are endemic to the strange ontologies of computational worldmaking per se, or whether is it simply that *worldmaking just isn't yet generative enough*. We hope that illuminating the possibilities and conditions of open-ended ontology in software may suggest how worldmakers can go about making worlds more inherently creative.

The habit of static thinking

Henri Bergson (1859-1941) is today curiously neglected. Well educated in mathematics, physics, and evolutionary and developmental biology, he became one of the mostly widely read and highly respected philosophers of his day.[6] By 1913, crowds gathering to catch his lecture, *delivered in French*, caused one of New York's first traffic jams; and in 1928 he received a Nobel Prize for Literature. Today he is best known through his influence on continental philosophers, particularly Gilles Deleuze, but his work also directly inspired many of the past century's great scientists, notably including Emil Post, who anticipated both Gödel and Turing's respective discoveries of formal incompleteness and undecidability; Norbert Wiener, who founded and named the field of cybernetics[7]; Walter Elsasser, a quantum physicist and early proponent of complexity in theoretical biology; and Ilya Prigogine, who won a Nobel prize for his work on the emergent, dissipative structures of irreversible, far-from-equilibrium systems:

> Since my adolescence, I have read many philosophical texts. I still remember the spell *L'Évolution Créatrice* cast on me. More specifically, I felt that some essential message was embedded, still to be made explicit, in Bergson's remark: 'The more deeply we study the nature of time, the better we understand that [it] means invention, creation of forms, continuous elaboration of the absolutely new.[8]

[6] Jacques Monod writes: "In my youth no one stood a chance of passing his baccalaureate examination unless he had read [Bergson's] *L'Évolution Créatrice.*" Monod, Jacques. *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology, trans. Austryn Wainhouse*. New York: Alfred A. Knopf (1971).

[7] Wiener, N. *Cybernetics or Control and Communication in the Animal and the Machine*, (Hermann & Cie Editeurs, Paris, The Technology Press, Cambridge, Mass., John Wiley & Sons Inc., New York, 1948).

[8] Prigogine, Ilya. (1977). *Autobiography*, Nobel Prize Organization.

Described as a "soft Copernican revolution" by William James, the challenging subtlety of Bergson's ideas unfortunately led to numerous misrepresentations and misunderstandings. Bergson's writing opposed prevalent scientific outlooks of his time, including the exclusivity of deterministic reductionism, the sufficiency of rational deduction, and the notion of time as fully reversible. Worse still, his positions stem from a key insight that works directly against the natural habits of the mind!

Like many philosophers, Bergson's critique begins from an under-appreciated limitation in our knowledge of the world; in his case *the static habit of the intellect.* Specifically: it is our natural habit to abstract discrete static snapshots of continuous flowing reality through the selective actions of perception. We "arrest time" to frame and dissect the world into distinguishable and manipulable terms, as the continuum of reality is otherwise too complex to negotiate: "Of the discontinuous alone does the intellect form a clear idea."[9] This habit is an evolutionary adaptation: a practical and effective method for satisfying our needs and controlling unruly environments.[10] No less than an amoeba, we perceive the world in problem-oriented terms, organized toward completion of actions that serve our interests. Our crucial error, says Bergson, is that once we postulate on the nature of the real, we mistake this selective bias as a condition for truth. By requiring that nature fit our habitually static scheme and excluding what cannot be thus assimilated, we end up with static ontologies that elide the creativity of time. These ontologies find themselves mired in paradoxes and problems of movement (from possibility to actuality, from absence to presence, etc.) that Bergson argues were badly posed to begin with.

[9] Bergson, 1907.

[10] We should not therefore be surprised that the intellectual conception of computing technology also began with the task of *calculating a result*, such as decoding an encrypted military message, or determining whether a given program will terminate.

Bergson's claim is borne out by the remarkable ascension and refinement of the intellectual habit over the centuries of Western philosophy. Russell and Whitehead's *Principia Mathematica*, published between 1910 and 1913, was intended to be an ultimate completion of purely symbolic and static axiomatics from which all mathematical truths can in principle be proven. Yet by 1931 Kurt Gödel had comprehensively demonstrated the incompleteness of this masterwork–and any other such attempt–by proving that there are true statements in any formal system whose truth cannot be derived from within the system." Gödel in the end declared that neither the synthetic nor the intuitive could be banished from either mathematics or logic, ratifying Bergson's claim that the limitations of intellectual processes are 'immanent to the method' of the intellect itself, and are incapable of being objectified."[11] Importantly for us, the limits claimed by Bergson appear regardless whether the method is carried out by natural or artificial means: Russell and Whitehead's system, and Gödel's proof, are both mechanizable. Moreover, Turing similarly showed, by means of a formal model of a mechanical solver proceeding in discrete

[11] Adamson, Gregory Dale. *Science and philosophy: two sides of the absolute.* Pli: The Warwick Journal of Philosophy 9 (2000): 53-86.

steps (a model that has come to be known as the *Turing Machine* and helped found computer science), that there are well-defined problems for which no computable solution is possible. The classic example is the *halting problem*: that no algorithm can universally determine whether any program will terminate or run forever. In fact these limits of incompleteness and uncomputability had been earlier discovered by Emil Post, who thus concluded that "mathematical thinking is, and must remain, essentially creative."[12] By interpreting these limits as traces of continuity in the process of thought, he attempted to found a creative logic more "in line with Bergson's *L'Évolution Créatrice* than Russell's *Principia Mathematica*."[13] Post's logic involves following algorithmic tasks, as with Turing Machines, but crucially it is given from the point of view of a creative worker that is *situated in time*. Through a method of reflection, this worker freezes the creativity of time into spatialized properties, symbols and relations, resulting in the *creation of algorithms*, in a mostly unconscious process carried out on a thoroughly Bergsonian plane.

The habit of static thinking remains deeply infused in our industrial and cultural inheritance. Russell and Whitehead's work continues to thrive in computer science via the Platonic essentialism of class-based inheritance, the formal foundations of type theory, the deductions of model-driven engineering, and so forth.[14] In many problem-oriented domains this is entirely appropriate, but toward open-ended worldmaking we must guard against its comfort and find ways to reconsider established practice. But can we really create worlds of autonomous creativity with a techné so deeply infused with and theoretically founded upon characteristics of static, mechanistic intellect?

To overcome the paradoxes that static ontologies lead to, Bergson demands a conception of reality as a whole that is continuous and creative, predicated not on a static notion of being, but rather on an enduring notion of becoming, which he calls *durée*.[15] As a *complement* to intellectual analyses composed of finite numbers of static snapshots of being, Bergson advocated a method of placing oneself inside the becoming of a subject, within its *tendencies*, from where it is possible to trace innumerable perspectives. This is subjective in no pejorative sense, since "the tendency *is* the subject. A being is not the subject, but the

[12] Post, E. *Recursively enumerable sets of positive integers and their decision problems.* Bulletin of the American Mathematical Society, 50:284–316, 1944.

[13] Post, E. Absolutely Unsolvable Problems and Relatively Undecidable Propositions - Account of an Application," in Davis ed. *The Undecidable: Basic Papers on Undecidable Propositions, Unsolvable Problems and Computable Functions.* Raven Press, Hewlett, New York, 1965. pp338–433.

[14] The reference to Plato is often explicit in the description of the relationship between objects and classes (akin to ideal forms) in object-oriented programming (OOP) languages such as Java and C++. In these dominant languages capabilities and behaviours of objects are only received "by inheritance" from the class presiding over them; and classes may only be defined prior to program execution. However this timeless separation of classes was not an original component OOP (Kay, Alan C. *The early history of Smalltalk.* History of programming languages II. ACM, 1996), and earlier languages in the lineage used dynamic *delegation* rather than static *inheritance*; relationships made and unmade as a program runs. By an odd cultural inversion these languages are not now widely regarded as primarily object-oriented.

expression of the tendency, and furthermore ... [only] in so far as this is contrasted with another tendency."[16] Bergson illustrates this by analogy to an arrow in flight: from within the process of motion itself, one can easily imagine stopping the arrow at any point, but tracing a series of immobile points does not recreate motion, since "there is more in the transition than the series of states, that is to say, the possible cuts."[17] Similarly, there is more in a real subject than in the abstractions we make of it; no matter how many views we take we never recover its entirety.

Bergson also famously referred to the analytic intellectual habit as "cinematographical", comparing the frames exposed by a film camera to the snapshots of knowledge we create by placing ourselves outside the flow of time.[18] Captured frames represent for Bergson exactly the opposite of reality: they make all moments equal, to the exclusion of the singular qualitative forces that created them. It seems easy to extend this criticism to the lowest levels of computing: programs are translated into a series of binary codes (an extreme case of making all moments equal) that execute discrete changes in state as they pass like the frames of a film through the CPU. How could an aggregate of stepwise states create real movement? To begin addressing this challenge, we will utilize Bergson's accounts of the tendencies of matter and of life.

Two tendencies

Bergson dedicates much of *L'Évolution* Créatrice to the creative tendency of *durée* as manifest in the specific example of biological life, characterized as a tendency to spontaneously increase in complexity and heterogeneity, which he named the *élan vital*. Sadly many readers mistook this to mean that Bergson counted among the vitalist thinkers, who hold that life differs from non-life because it carries some mysterious, non-physical essence, a progressionist urge directing life toward higher goals. In fact Bergson was as deeply critical of the transcendental character of vitalism as he was of the reductive dogmatism in mechanist thought, and rejected both as inadequate. In subsequent decades, as biology turned increasingly to chemistry and physics for its foundations, vitalism rapidly became obsolete; and through this misconception of the

[15] This word is usually translated as *duration*, however we will retain the French *durée* in order to avoid ambiguity with the common sense of the term as a *period*. What Bergson intends is a more profound yet subtle notion, which in Deleuze's analysis resolves to pure difference itself (Deleuze, G. *Bergson's Conception of Difference*. In The New Bergson, ed. Mullarkey, J. Manchester University Press, 1999).

[16] Deleuze, 1999.

[17] Bergson, 1907. We find it curiously resonant with Norman McLaren's renowned statement that "Animation is not the art of drawings-that-move, but rather the art of movements-that-are-drawn. What happens between each frame is more important than what happens on each frame." Norman McLaren, circa 1955. In Georges Sifianos, "The Definition of Animation: A Letter from Normal McLaren", *Animation Journal* 3, 2 (Spring 1995): 62-66.

[18] Note that Bergson's "cinematographical" analogy is not criticizing the art of cinema, rather the assumption that discrete snapshots are sufficient to capture the vitality of the world. We return to a thoroughly Bergsonian account of cinema later in the chapter.

élan vital Bergson became incorrectly dismissed as irrelevant to modern thought. However, we note that Nobel prizewinner Jacques Monod, in his manifesto of materialist biology *Chance and Necessity*, also appreciated the important difference between Bergson's thought and vitalism–in that Bergson rejected final causes (ultimate purposes) as consistently as efficient causes (predeterminations). It was only a "postulate of objectivity" that forced Monod to exclude Bergson, to which we need not adhere.[19] Rather than fighting misconstrued terminology, we will focus on the way Bergson distinguished the tendencies of life from those of matter.

[19] Monod, 1971.

The general tendency inherent to matter is to "de-tensify"[20] into extended spaces of simpler homogeneities, whereas life shows an inverse tendency to interrupt this tendency by "infolding" it, thus differentiating into new structures and behaviours. In light of the subsequent century of research there is nothing mystical in these statements. The second law of thermodynamics teaches us that matter is fundamentally entropic, tending toward its ultimately most probable state of statistical homogeneity. In this state no useful work can be done, since no significant energetic differences remain. Accordingly, living systems must actively perform processes to maintain negative entropy, keeping themselves far from equilibrium states, as was famously recognized by Erwin Schrödinger.[21] Consider Bergson:

[20] The term used by Bergson is *détente*, which in some translations is given as *relaxation.* As with *duration* for *durée*, we avoid this usage in an attempt to reduce ambiguity with the conventional meaning of the term.

[21] Schrödinger, Erwin. *What Is Life? The Physical Aspect of the Living Cell and Mind.* Dublin, 1943.

> Life is riveted to an organism that subjects it to the general laws of inert matter. But everything happens as if it were doing its utmost to set itself free from those laws... [Life] has not the power to reverse the direction of physical changes, such as the principle of Carnot determines it... Incapable of stopping the course of material changes downwards, it succeeds in retarding it... All our analyses show us, in life, an effort to re-mount the incline that matter descends. In that, they reveal to us the possibility, the necessity even of a process the inverse of materiality, *creative of matter by its interruption alone.*[22]

[22] Bergson, 1907 (emphasis added).

Because of matter's homogeneity, we can often approximate and predict physical phenomena incorporating millions of dynamic elements in terms of a small number of final attractor states: the equilibria that minimize free energy. However in conditions maintained far from equilibrium, where matter's tendencies are interrupted, complex new structures and organizations can arise from local interactions, preventing such convenient approximations.[23] The apparent *creativity* of systems maintained far from equilibrium was recognized and popularized by Prigogine, bringing scientific rigour to research in *self-organization*.[24] In the language of complex dynamics, we live on the long transients we construct to keep us far from the simple attractors for as long as we can.[25] Which is to say, a biological organization is a process that is forever incomplete, preserving its own problem from reductive simplification into an ultimate (dis)solution.

[23] A simple example demonstrates the ontological necessity of creative organization: without it, the material contents of an animal have the complexity and behavioural tendencies of soup. It is immeasurably easier to move from animal to soup than from soup to animal.

[24] Nicolis, Gregoire, and Ilya Prigogine. *Self-organization in nonequilibrium systems.* Wiley, New York, 1977.

[25] To clarify the misconception of the *élan vital*, we can identify it as "immaterial" only in the sense that it is a quality of organization that opposes (delays) matter's tendency to simplify.

Crucially, not only does this hint at what *kinds* of processes we may need to look for, it also suggests that life-like creativity may inhabit computation no less than life inheres in matter.

For Bergson is making no dualism, and there is no special boundary or added essence that separates the living from the non-living:

> The progress must be continuous, in nature, from the beings that vibrate almost in unison with the oscillations of the ether, up to those that embrace trillions of these oscillations in the shortest of their simple associations. The first feel hardly anything but movements; the others perceive qualities. The first are almost caught up in the running-gear of things; the others react and the tension of their faculty of acting is probably proportional to the concentration of their faculty of perceiving.[26]

[26] Bergson, 1907.

Distinguished biologists such as Ernst Mayr and Manfred Eigen have identified information transformation as a characteristic distinguishing life from the physical world, *with the possible exception of computers.* Conversely computational treatments of life's creativity can be traced back to John von Neumann's proposal of a self-replicating machine using cellular automata in the late 1940s.[27] Christopher Langton demonstrated a more compact self-replicating computer organism in 1979, and a decade later announced the field of *Artificial Life*.[28] The field begins with the premise that *life is a process of transforming organizations*, not of a property of a particular material or medium; a premise whose stronger interpretation holds that life *is* possible within computation. Bergson similarly articulated that life is not tied to the specific example we know of, but it is possible *wherever a matter-energy principle descends while a very different organizational principle ascends*.[29]

[27] von Neumann, J. *Theory of self-reproducing automata (lecture), University of Illinois, 1949.* In *Lectures on the Theory and Organization of Complicated Automata*, ed. Burks A. W., University of Illinois Press, Urbana IL, 1966.

[28] Langton, C. G. *Artificial Life: An Overview.* MIT Press, Cambridge, MA, USA, 1995.

[29] Bergson, 1907.

Differences in kind

To clarify this difference, Bergson notes that while matter-energy can be measured and exchanged equally, making it a *quantitative* generality (forming differences of degree, or number), the creative impulse of organization found in life is not so easily compared: by forming particular structures of behaviour with individual tendencies, it is *qualitative* in nature (forming differences in kind). The vital creativity of Bergsonian time inheres in *the continual production of new tendencies*[30]; for if not it would be of no more significance than merely quantitative states of matter–"time is invention or it is nothing at all."[31] Indeed Bergson's distinction can be rephrased that while the division of matter forms quantitative change, "everything that Bergson says about durée always comes back to this: *durée is what differs from itself* ... what changes in nature in dividing itself."[32]

De Landa[33] and Protevi[34] have elaborated the above-noted resonance between Bergson's tendencies and the roles played by attractors in dynamical systems. A dynamical system is described through the necessary relations between its significant degrees of freedom, revealing the attractors that dominate its long-term behaviour. Successfully applied across a diversity of physical sciences, over the past century dynamical systems have increasingly been introduced to biology; however as De Landa makes clear, the need to specify degrees of freedom in advance makes them inadequate to capture life's constructively divergent organizations, since the phase space through which the system's changes are described cannot itself change. One method proposed to overcome this limitation is to employ *rewriting* systems, such that "the structure of the phase space must be computed jointly with the current state of the system", and "the organization of this set is subject to possible drastic changes in the course of time."[35]

This suggests an attractive route toward durée, since the capacity to rewrite itself, to differ from its prior processes, couldn't be more essential to computation. Of the capacities that differentiate computing from simpler machines is the ability to divert or *interrupt* conventional flows of control, generally recognized in conventional code through constructs such as "if()", "while()", and so forth. The most radical of these control-flow constructs is *dynamic loading*, which means loading new data into

[30] Deleuze (1999): "It is not things nor states of things which differ in nature, it is not characters, but tendencies... The conception of specific difference is not satisfactory: it is not to the presence of properties that we must pay attention, but to their tendency to develop themselves." Bergson (1907): "The group must not be defined by the possession of certain characters, but by its tendency to emphasize them."

[31] Bergson, 1907.

[32] Deleuze, 1999.

[33] De Landa, M. *Intensive Science & Virtual Philosophy.* Continuum International Publishing Group, 2005.

[34] Protevi, J. *Deleuze, Guattari, and Emergence.* A Journal of Modern Critical Theory, 29.2 (July 2006): 19-39.

[35] Giavitto J, and Michel, O. *MGS:: A Rule-Based Programming Language for Complex Objects and Collections.* Electronic Notes in Theoretical Computer Science, vol. 59, no. 4, pp. 286–304, 2001. It is appealing that the combination of rewriting with dynamical systems is able to subsume a vast range of previously discrete models, from evolution to population dynamics to multi-cellular development to neural adaptation.

memory and interpreting that data as code to run.[36] As Langton puts it, "computers should be viewed as second-order machines–given the formal specification of a first-order machine, they will 'become' that machine."[37] Moreover, through the symbol-processing capabilities at the heart of computing, programs can also *create* other programs. That is, computation comprises "mechanisms in which things build other things. Such 'things' are processes."[38] Together, the dynamic creation and loading of code permits a program to literally rewrite itself while it runs. As a result, and in contrast to the static state space of a regular program, the state space of a self-rewriting program is both cause and product of an in-time process. Such flexibility is not generally recommended for conventional software due to the unpredictability it implies[39], but it remains essential necessity in computing–without it, there would be no compilers to build apps, nor operating systems on which they run. And for our purposes, unpredictability is a minimum criterion, for creating a Bergsonian world is not a conventional software problem.

Rewriting also seems necessary to achieve Post's description of reflective processes that result in the creation of algorithms, but we must also be careful not to mistake the word "rewriting" for a return to the static limits of formal language. Overcoming Bergson's critique in this regard may seem extraordinary–programmers code programs in programming languages, pre-existing formalisms whose transcendent grammars could not be more deeply linguistic–yet again, we should not mistake the habit of coding for the reality of computation.

Pre-linguistic self-modulation

> What should be grasped and given form are the things that are in flux. – *Viking Eggeling*, circa 1920.[40]

Oddly enough, we may illuminate this via a brief detour through Deleuze's analysis of the myriad qualities of movement and time in cinema.[41] Deleuze rejected the linguistic bias of semiology permeating contemporary film theory by understanding cinematic images as *pre-verbal* yet nevertheless intelligible signs, rather than *a priori* coded signs of

[36] This is no new idea; it is at least as old as LISP (McCarthy, J. *Recursive functions of symbolic expressions and their computation by machine, Part I.* Communications of the ACM 3, 184–195. 1960). Dynamic loading is explicitly described as a form of control flow in Fisher, D. A. (1972, November). *A survey of control structures in programming languages.* ACM SIGPLAN Notices 7(11), 1–13.

[37] Langton, 1995.

[38] Fontana, W., Wagner, G. and Buss, L. W. *Beyond Digital Naturalism.* Artificial Life, 1 & 2. MIT Press, 1994.

[39] It is difficult to optimize a program whose bounds of behavior are not known in advance. Reducing the potential dynamism of a program makes it more predictable, which is considered important for safety and stability, regardless whether the program's task is to send an email, calculate a credit rating or guide a lunar landing. In contrast, outside of academic research, self-modifying code is most widely seen in computer viruses, where predictability is a weakness.

[40] In Hans Richter, "EASEL—SCROLL—FILM", Magazine of Art, February 1952: 88. Both Eggeling and Richter addressed the non-objective sensation of art as a *process*, developing through scroll painting and subsequently abstract animation.

[41] Deleuze, Gilles. *Cinéma II: L'image-temps*, 1985.

a language.[42] That is, the signifying capability of the cinematic image exists prior to any crystallization into language. Moreover, these semiotic qualities of an image are the very same underlying *signaletic material* of which the sights and sounds of the material world consist. In this way, Deleuze's use of the world *image*, also drawn from Bergson, encompasses a much broader concept than the visual content of the frame. Bergson used the term *image* not to refer to a visual representation, but as a way to describe the contents of reality without becoming mired in either side of a mind-body dualism (neither solely material substance nor immaterial idea).[43] As with *durée*, the choice of terminology is unfortunately misleading, but consider an *image* to be a placeholder term for any discernible thing, center, or process, that may be more or less material, more or less of the mind. The Bergsonian universe is an aggregate of intersecting and interacting images, some interacting in ways we can describe as natural laws.[44] Regardless of philosophical commitment, the inclusivity of the term *image* and its evasive stance with regard to substance is conducive to our goal, since a rock in a virtual world is no more or less material, no more or less of the mind, than is a database, a subprogram, or an artificial life agent. Most importantly, Deleuze is clear that although the "signaletic" material of the image is not primarily structured by relations to a pre-existing linguistic code, nor is it indeterminate or shapeless. Rather, a sign's meaning arises according to the nature by which its material is embodied within the image, in "a self-modulation that is independent of transcendent structures."[45] Similarly, whereas software engineering is typically qualified in terms of concrete referents outside of itself–schema imposed by developers, architects and users–nature herself needs no external referent, no efficient or final cause, to have significance. If we are to approach her creativity, we must put aside inherited habits of computing practice, and regard instead the underlying self-modulations that the computational medium makes possible.

Our first step in escaping linguistic bias for computation is to carefully distinguish *program-as-process* as ontologically anterior to *program-as-text,* noting that the reality of the computing machine as a physical energetic process effectively precedes the behaviours we request of it.[46] It is neither the specific instructions executed nor their results that characterize the

[42] If pre-verbal intelligibility seems oxymoronic, consider how communication between and within biological organisms and their environment cannot appeal to an a priori protocol. There is a contemporary science of *biosemiotics* studying the production and interpretation of such signs in biological systems, for which mechanistic frameworks are held inadequate. Barbieri, Marcello, ed. *Introduction to biosemiotics: The new biological synthesis.* Springer Science & Business Media, 2007.

[43] Bergson, Henri. Matière et Mémoire. 1896. (Matter and Memory 2004. republication of 1912 MacMillan edition. translators N. Margaret Paul and W. Scott Palmer. Dover Publications.) It is this work to which Emil Post referred as the plane on which the *creation of algorithms* occurs.

[44] In several regards, Bergson's *image* is congruent with Bogost's *unit operations*, which are similarly opposed to the pre-ordained/transcendent nature of static systems, and posited explicitly to help bridge a range of fields spanning philosophy and the worldmaking of videogames. Moreover, Bogost appreciates the concrete universals of Graham Harman's object-oriented philosophy, also prefigured in Bergson. Bogost, Ian. *Unit Operations: An approach to videogame criticism.* MIT Press, 2008.

[45] Dawkins, R. *Deleuze, Peirce and the Cinematic Sign.* The Semiotic Review of Books 15.2: pp8-12, 2005 (emphasis added).

medium as a material process. Using the Bergsonian method of placing oneself within the "becoming" of its tendencies, one finds first a continual interplay between reading data from an input stream and actualizing corresponding internal changes; an eternal return to the question of "what to do next?" There is no more linguistic essence in this material organization than there is in a string of DNA or in the frame of a film. The fact that programs are represented to us as code leads to a convenient illusion of reducibility to static data, which obscures the creative power of the process. Programming languages are merely conveniences to make machines amenable to us, but for the machines human-readable code is irrelevant–it is entirely possible for programs to be algorithmically generated and executed that no human authored nor is able to understand–with the machines principally indifferent to the intelligibility of the effects. The machine self-modulates; we build semantics upon it.

[46] Shagrir. O., "Two Dogmas of Computationalism." *Minds & Machines* 7 (3), 2008, pp. 321-344.

For our purposes, to embody durée, a computational world must retain the "second-order" capability to become other, to continually rewrite itself in unscripted ways, making the constructive creativity of computation a concrete and active part of its actual process. By doing so the transcendental distinction between the world-as-process and its description-in-code is eroded, as the latter is now concrete and manipulable within the former. In contrast to the derived purposes of conventional programming, such a living world directs its production from within.[47]

[47] We described this endogenous component of our art practice in Ji, H., and Wakefield. G., *Endogenous Biologically Inspired Art of Complex Systems.* IEEE computer graphics and applications 36.1 (2016): pp16-21.

We can anticipate some counter-arguments of this point. First, beneath any self-modifying machine there must be a substrate that does not have this capacity, a lower bound on what is modifiable at runtime. But similarly, Bergson is clear that his matter-life distinction is only ever partial, that life can never become fully contracted into pure *durée* and escape the mixture with the tendencies of matter–nevertheless this does not make life reducible to matter. Second, the behaviour of any deterministic self-modifying machine can be shown to be formally equivalent to a non-self-modifying machine: no matter how complex the self-modification, a deterministic process depends only upon its starting conditions. But formal equivalence does not capture what is significant in an interestingly creative process; the equivalent system may be unreasonably large, impractical to run, or even intractable to find. Both counter-arguments prefix the capacities of computation in reductive terms–of formal equivalency and mechanical substrate. That Bergsonian creativity appears impossible in such perspectives is a limitation of the perspectives themselves. To remark that a computational system has such a mechanistic underpinning is not only tautologous, it neither precludes nor helps to delineate the kinds of organization we seek.[48] To capture qualitative nature we must take the perspective from *within* an actual process, incorporating the interwoven contingencies that make it particular rather than general. The better question is what conditions are required to maximize its expression.

[48] "Virtuality could only differentiate itself using the degrees which coexist in it." Deleuze, 1999.

Strongly constructive inhomogeneity

At the very least, there must be more in the unfolding *program-as-process* than in the static abstraction that the *program-as-text* reveals to us. Although in the logic of computing Laplace's conjecture holds true–that from any complete description of the initial conditions, its entire future can be theoretically deduced–this does not mean it can be practically predicted. The halting problem demonstrated this, but for a simpler example consider a pseudo-random number generator (PRNG): a trivial recursive procedure that produces a series of numbers that seem random. It is only *pseudo*-random because it is actually deterministic: the same initial "seed" condition will produce the same sequence of numbers every time. Yet it confounds prediction, in that the fastest way to determine the 1000th number is to run the algorithm 1000 times. The information in the *process* is staggeringly larger than the information in the *code*. Its unfolding history cannot be randomly accessed–or in Bergsonian terms, *spatialized*–without ceasing to be computation.

It must also be noted that even though the sequence generated by even the best PRNG will eventually repeat in entirety. Yet if the sequence length is larger than the number of invocations likely during a program's lifetime, this repetition will never *actually* occur. Konrad Zuse, architect of the first working universal Turing Machine and an early proponent of the computationalist stance (that the universe itself may be a deterministic automaton), remarked that if "in spite of [the vast duration of the universe] only a vanishingly small portion of the possible states of the cosmos can exist... of what value is the realization that the evolution of the universe follows a periodic cycle?"[49] Elsasser put forward a biological example: "If one represents each theoretical configuration of a complex biological object, for instance a protein, by a point in an abstract state space, then the state space thus constituted is immensely large, and the fraction of that theoretical state space actually occupied in the real world is vanishingly small."[50]

[49] Zuse, K. (1969). *Rechnender Raum*. Schriften zur Datenverarbeitung. Vieweg.

[50] Gatherer, D. (2010). *So what do we really mean when we say that systems biology is holistic?* BMC systems biology, 4(1), 22.

Confounding exact predictability is necessary but clearly insufficient to capture the open-endedness we appreciate in nature. Although we cannot easily predict specific values of a PRNG, its stochastic distribution over a number of samples quickly converges (whether uniform, Gaussian, etc.). Its statistical homogeneity is what makes it useful as a *tool*, but at the same time matter-like and uncreative. Elsasser states that to avoid such collapse into the readily reducible mode of matter, processes must not only be capable of producing a vast number of states, but also that the states produced in a given run must *not* be statistically representative of all possible states.[51] Elsasser characterizes such processes as generating *inhomogeneous* classes, because general properties of the possible space and the actual space (such as average point) can be radically different. By breaking symmetries of the possible, we are no longer justified in generalizing from theory to actuality.[52] The combinatorial nature of rewriting systems makes it very easy to ensure that the number of significantly different possible configurations is vastly larger than the number that can actually occur at run-time, but what we need now is a mechanism to ensure what is generated is inhomogenous.

Also following a biochemical inspiration, Fontana et al. distinguished *strongly constructive* systems, in which the effect of two agents' meeting is determined principally by the internal properties and capacities of the agents, from *weakly constructive* systems in which the effect is determined stochastically.[53] Populations of complex molecules such as protein polymers are strongly constructive, since the relationships between proteins depend (in non-trivial ways) upon their shape and features. They are also deeply *contingent*: new proteins are added to the actual set only if there is a reaction path from what already exists. This historical, evolutionary process naturally results in an inhomogenous set of proteins non-repre-

[51] In this regard much generative art is not generative enough.

[52] This argument demonstrates that the contingent history of a theoretically reducible system may not *in actuality* be so reducible, and thus how a life inhering in matter may nevertheless remain irreducible to it. Indeed Elsasser suggested that von Neumann's *Grundlagen proof*–that quantum indeterminacies average out to Newtonian mechanics at the macro-scale–might not apply for sufficiently complex inhomogenous molecules, such as proteins, and that accordingly, life might in fact be influenced by the indeterminacies of quantum mechanics in ways not reducible to statistical Gibbsian thermodynamics. Gatherer, Derek. *Finite universe of discourse. The systems biology of Walter Elsasser (1904-1991).* Open Biology Journal 1 (2008): 9-20.

[53] Fontana et al., 1994.

sentative of all possible proteins.[54] Echoing Bergson's two tendencies of life and matter, strongly constructive systems can prolong inhomogeneous difference by creating a contingent history (time as invention), whereas weakly constructive systems gradually erase both.

[54] Kauffman, S. *Investigations*. Oxford University Press, USA. 2002.

But this still doesn't ensure that they *will*. In that regard Kauffman suggested that, beyond a sufficient diversity of polymers, the expansion of this history is inevitable and self-sustaining. The argument is that if each currently possible reaction is catalyzed by at least one other actual protein, the network of all actually possible reactions becomes collectively autocatalytic (self-generating). As the diversity of proteins increases this becomes far more probable. Moreover, due to the combinatory nature of polymers, at the edges of this network there are new compound products that did not previously exist, and toward which there are reaction gradients encouraging their production. Any such compounds that can find a productive role within the network are viable and will be reproduced. The result is an inevitably self-constructing, non-ergodic universe: a space too large to ever fully exist, but which cannot help but expand, tracing a unique and particular history of existence. It is perhaps a chemical variation on a much earlier computational story given by von Neumann:

> There is thus this completely decisive property of complexity, that there exists a critical size below which the process of synthesis is degenerative, but above which the phenomenon of synthesis, if properly arranged, can become explosive, in other words, where synthesis of automata can proceed in such a manner that each automaton will produce other automata which are more complex and of higher potentialities than itself.[55]

[55] von Neumann, 1945.

Both stories seem to come together in Fontana's "artificial chemistry", a self-constructing computational system of autocatalytic expansion. In this system a collection of short expressions of the lambda calculus (equivalent to simple Turing Machines) are allowed to meet in pairs selected at random, as if in a stirred chemical reactor. One of the pair is evaluated with the other as its input, producing a new expression as the "reaction product". To visualize this differently, consider each "chemical" as a simple program, recalling that programs can be viewed as either process or data (machine or tape). A reaction takes one machine at random and runs it (treating it as a machine), using another machine as its input (treating the second program as tape).[56] A large population of "chemicals" is active at any time, operating under a far-from-equilibrium gradient maintained by continually removing "inert" (defective) or "uninteresting" products, and replenishing with raw materials (primitive machines). The system is clearly self-rewriting, strongly constructive, and contingent. And in fact, beginning simulations with only very simple machines, Fontana observed the autonomous emergence of not only complex machines collaborating in autocatalytic cycles, but also higher-level organizational processes strongly indicative of life-like evolution.

[56] Fontana, Walter. "The topology of the possible." In *Understanding Change*, pp. 67-84. Palgrave Macmillan UK, 2006. Related results where earlier reported in Ikegami, Takashi. *Evolvability of machines and tapes.* Artificial Life and Robotics 3.4 (1999): 242-245.

While Fontana's artificial chemistry satisfies many of our suggested conditions, and encouragingly leads to increasing complexity, like many artificial life simulations it does eventually reach a "complexity ceiling" at which new classes of phenomena no longer seem to manifest. Whether this is simply a matter of scale or due to something more fundamental is not yet clear.

Curious Participation

Thus far we have traveled into the endogenous self-modulations of the machine, but we have not addressed how such modulations become expressive or meaningful worlds. Here we can return to Deleuze's use of the Bergsonian concept of *image*, which is not just agnostic to the mind-body problem, it is explicitly both objective and subjective: our own bodies are images within a sea of images, and our perceptions are these same images oriented toward our possibility of acting upon them.[57] This continuum is what allows Deleuze to consider the viewer on a plane shared with the filmic: that perceptions of cinematic images engage our automatic action-oriented body-image, and the intellectual and affective intervals our minds impart, feeding back into the unfolding film experience. Contra Bergson's cinematographic metaphor, "cinema does not give us an image to which movement is added, it immediately gives us a movement-image"[58], and the art of montage is the creation of new movement, not the *recreation* of an existing movement.

[57] Bergson, 1907.

[58] Deleuze, 1985.

A similar claim is made with respect to the simulacra of computational worldmaking. Considering Casey Reas' *{Software} Structures*[59], Whitelaw observes that the use of simulation and the visualization of relations in agent-based systems impart a metaphorical quality through perceptual resonance. Each work speaks to us and our world through its characteristic behaviours, which in turn follow from the ontology at its core: "These works are fundamentally determined by this ontology, and in a basic way *we see it in the works.*"[60] And in our view, the more worlds also engage with us *corporeally*–with the body as image within a sea of images, through our actions as well as affectations–the more they may form the foundation of meaningful experience.[61]

Whether or not the appeals to algorithmic unpredictability, inhomogeneity, and contingency made above are sufficient to diffuse the argument that no machine in the classical model of computation can originate the indetermination needed for durée, the introduction of interactivity may introduce forms of indetermination to the machine of a wholly different kind. Bergson argued that the terms "indeterminacy" and "disorder" indicate what the intellect cannot assimilate, and what a static machine cannot assimilate is its external world, what lies beyond its original frame. In early computing this frame was a hard boundary: programs were written and input specified before starting to run, results of interest were given only after the program halts. But as soon as programs were made sensitive to external conditions at runtime, they escaped total determinism: behaving like deterministic Turing machines between each interaction point, but changing indeterminately over interaction points.[62]

Indeed there is a hotly debated question of whether interactive machines should be considered to have greater computational capacity than universal Turing machines.[63] We note that Turing also theorized a transcendent machine, called an *Oracle*, or *O-machine*. This augments a regularly deterministic universal Turing machine with an additional infinite tape of read-only data, corresponding to the decisions of some non-mechanizable question. Turing proposed the O-machine concept in order to integrate formally-defined yet incomputable mathematical relations, such as the decidability of whether a given program will halt.[64] However we can also use O-machines to consider interactivity: the state

[59] http://artport.whitney.org/commissions/softwarestructures/map.html, accessed July 2015.

[60] Whitelaw, 2005 (emphasis added).

[61] Bodily phenomenology is not only essential to virtual reality, it has moreover been argued that the body is the foundation of metaphor and the construction of meaning. Johnson, Mark. *The meaning of the body: Aesthetics of human understanding*. University of Chicago Press, 2008.

[62] We note a similarity with the "irrational cuts" in Deleuze's treatment of cinema: incommensurable links between shots that subvert the otherwise rational narrative flow, and thus present direct images of time (Deleuze, 1985). (The term is itself taken from a Dedekind cut in number theory, representing an intersection that belongs to neither of the sets it divides.) There is not space to fully elaborate the relationship between Deleuze's time-image and generative worlds in this chapter, which is reserved for a future essay.

[63] Wegner, P. and D. Goldin (2003). *Computation beyond Turing machines*. Communications of the ACM.

[64] Turing, A. M. (1939). *Systems of logic based on ordinals*. Proceedings of the London Mathematical Society 2(1), 161–228.

of an interactive input cannot be reduced to a deterministic procedure, but only represented as a non-mechanized question, an observation with a discrete result such as "is the joystick button currently pressed?" Reading sensor inputs measures the external world's incomputable differences of kind into actualized differences of degree, but the world itself remains incommensurable in general. Viewed from within the process of the Turing machine, it is our external world that introduces the most pure action of durée.

Nevertheless, the external world is not entirely without structure, and nor are the behaviours of humans. To the machine armed with sensors our actions may initially appear as inexplicable as locally entangled quantum particles or high-dimensional cross-sections, but there are nevertheless patterns that can be found. Per information theory, a system can try to characterize the data received by external inputs statistically, but only as a progressive adaptation that can never be complete–indeed this is a challenge faced by all living organisms.[65] Even without any a priori protocol, we need only the ability to create associations and a selective pressure to retain those that successfully integrate with the world, such as dissolving those programs that cannot associate with activity in sensors while replicating and rewriting those programs that can. Indeed Jürgen Schmidhuber, better known for his ground-breaking work on deep-learning neural networks now popularized by Google, has also put forward models of creativity and curiosity for intrinsically motivated, self-improving machines.[66] Considering a computationally-limited observer of the world, armed with a capacity to rewrite itself, external data is considered *interesting* if it leads to a better (or more compressed) predictive capacity of the world. Curiosity is the motivation that allows such progress, because the discovery of previously unknown regularities is non-arbitrary data. That is, *interestingness* is the first derivative of algorithmic compressibility: the steepness of the learning curve of being in the world. The adaptive system actively explores and deepens understanding of our world through interaction, without any pre-ordained structure, and the more a world can respond to us, and us to it, the more nascent relationships and dialogue may evolve in the participating human-computer whole, which were not formally specifiable in advance.

[65] A relevant recent example is Takehashi Ikegami's *Mind Time Machine*, an interactive art installation incorporating multiple cameras and projectors coupled to a complex adaptive neural network. Data collected over several months revealed significant thresholds of increasing complexity and autonomous organization. Ikegami, T. "A design for living technology: Experiments with the mind time machine." *Artificial life* 19.3_4 (2013): 387-400.

[66] Schmidhuber, J. "Formal theory of creativity, fun, and intrinsic motivation (1990–2010)." *Autonomous Mental Development, IEEE Transactions on* 2.3 (2010): 230-247.

Making a world more genuinely creative means increasing its rate of rare events without simultaneously diminishing their rarity–which is to say, creating events whose primary discernment resists quantitative simplification. To amplify Bergsonian open-endedness, we thus seek systems that not only engage with our minds and bodies, but which are actively motivated to preserve themselves away from predictable tendencies, by amplifying sensitivity to the most interesting of external indeterminacies, and prolonging their differences and preserving their incompleteness through rewriting themselves along contingent histories of strongly constructive endogenous processes, vast in possibility yet inhomogeneous in actuality. In this direction we head.

CYBERNETIC

Beyond Design: Cybernetics, Biological Computers and Hylozoism

Andrew Pickering

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We tend to think of technology as a unitary category, as if we could have a single, unitary philosophy of technology. Martin Heidegger [1], for example, thought that the essence of technology is a project of *enframing*, of putting the world at our disposal, and that science is the means of achieving that. We dominate nature through knowledge: science gives us access to the levers of power, and at the same time, we enframe ourselves, becoming parts of a posthuman assemblage of production and consumption. I think Heidegger was right. The last few centuries can be characterised by an ever-growing assemblage of knowledge and power, science and technology, which does enframe the world and ourselves within it. I don't see why we should not have a unitary philosophy of that assemblage: Heidegger is a good place to start.

[1] Heidegger, M. 'The Question Concerning Technology,' in D. Krell (ed.), *Martin Heidegger: Basic Writings* (New York: Harper & Row, 1976 [1954]), pp. 287-317.

That is not what I want to talk about. The history of British cybernetics offers us a different form of science and engineering that does not seek to dominate nature through knowledge. I want to say that one can distinguish *two different paradigms* in the history of science and technology: the one that Heidegger despised, which we could call the Modern paradigm, and another, cybernetic, nonModern, paradigm that he might have approved of. This essay focusses on some work in the 1950s and early 60s by two of Britain's leading cyberneticians, Stafford Beer and Gordon Pask, in the field of what one can call biological computing. My object is to get as clear as I can on what Beer and Pask were up to. At the end, I will discuss Beer's hylozoist ontology of matter, mind and spirit. This material is not easy to get the hang of—but that is what one should expect from an unfamiliar paradigm. [2]

[2] For more on British cybernetics, including the work of Beer and Pask, see Pickering (2002, 2004a, b, 2005a, b).

As a first pass through my topic, let me start with some work that is in the same spirit as Beer and Pask's, though less ambitious, and which is going on now. If you look on the web, you can find a project in the Arts, Computation and Engineering Masters Program at UC Irvine undertaken by Garnet Hertz, entitled 'Control and Communication in the Animal and the Machine.' [3] This title is a direct quotation of the much-cited subtitle of Norbert Wiener's 1948 book, *Cybernetics*, the book which introduced the word 'cybernetics' to the public. We can take this project, then, as a piece of self-consciously cybernetic engineering. What is it? It is a cockroach-controlled robot.

[3] www.conceptlab.com/control/—and follow the links for more information. Since I first looked at this site (21 July 2005) the title of the project has been changed to 'Cockroach Controlled Mobile Robot,' though the previous title is still listed too. I am extremely grateful to Ellen Fireman for first telling me about this project, and to Garnet Herz for telling me more about it when I visited Irvine in October 2005.

In Figure 1, a giant Madagascan cockroach stands on the white trackball at the top of the assembly, attached by Velcro on its back to the arm which loops above the other components. Motions of the cockroach's legs rotate the trackball which in turn controls the motions of the cart (much as a trackball can be used to control the motion of the cursor on a computer screen). Infrared sensors detect when the cart is approaching an obstacle and trigger the appropriate light from an array that surrounds the roach. Since roaches tend to avoid light, this causes the roach to head off in another direction. The entire assemblage thus explores its environment without hitting anything or getting stuck—ideally, at least. So what?

What is singular about this assemblage is the cockroach. Over the past twenty years or so, many autonomous robots similar to Hertz's have been built, but their intelligence resides in electrical circuitry, not an insect. The first of these were small robots built by another of my cyberneticians, Grey Walter, in the late 1940s (Figure 2)—he called them tortoises, or *Machina Speculatrix*.[4] [5] They had, as he put it, two neurons, each composed of an electronic valve, a capacitor and a relay switch. The present-day descendants of the tortoises have silicon chips instead to supply their intelligence. So here we come to a first contrast: in Hertz' robots, a roach takes the place held by a computer in conventional robotics—and hence the phrase *biological computing*—the roach-as-computer.

We need to think further about this contrast. We can note that centuries of engineering and science go into the manufacture of valves, chips and electronic circuits in general. The human race has had to accumulate an enormous amount of material infrastructure, knowledge and expertise to put us in a position to build and program computers. Hertz instead needed to know *almost nothing* about roaches to build his machine. The roach remains, in a cybernetic phrase, a *black box*, known only in terms of its performative inputs and outputs—it runs away from light, and that's it. If the construction of a conventional robot entails ripping matter apart and reassembling it in accordance with our designs, Hertz's involves a different strategy: *the entrainment of the agency of nature*, intact into a human project, without penetrating it by knowledge and reforming it.

[4] Walter, W. G. *The Living Brain* (London: Duckworth. 2nd ed. Penguin 1961 [1953]).

[5] Pickering, A. (2004b) 'Mit der Schildkröte gegen die Moderne: Gehirn, Technologie und Unterhaltung bei Grey Walter,' transl. by Gustav Rossler, in Henning Schmidgen, Peter Geimer and Sven Dierig (eds.), *Kultur im Experiment* (Berlin: Kulturverlag Kadmos, 2004), pp. 102-119. English version: 'The Tortoise against Modernity: Grey Walter, the Brain, Engineering and Entertainment,' in *Experimental Cultures: Configurations between Science, Art, and Technology*, 1830-1950 (*Berlin: Max Planck Institute for the History of Science*, Berlin, preprint 213, 2002), pp. 109-22.

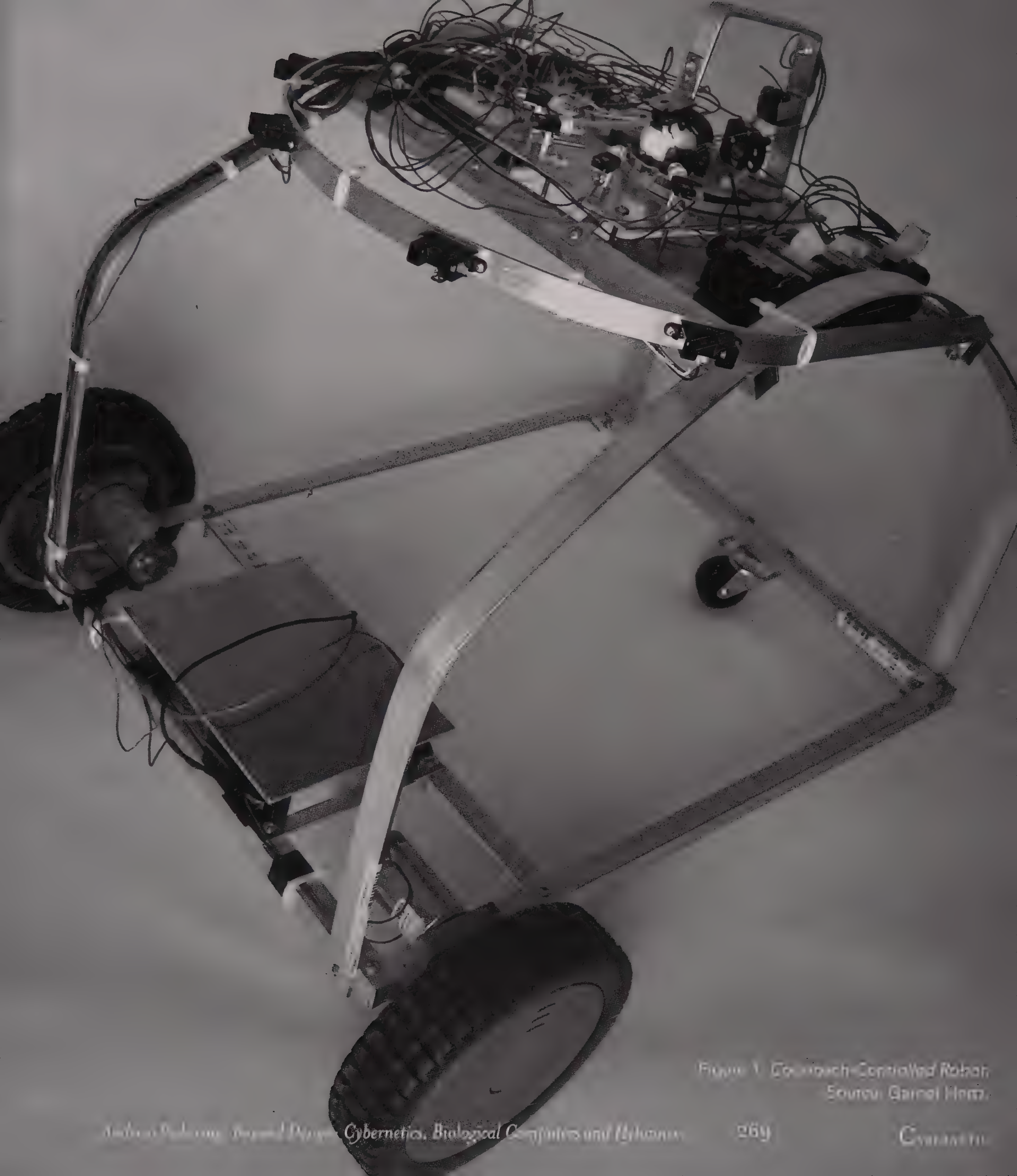

Figure 1. Cockroach-Controlled Robot.
Source: Garnet Hertz.

Figure 2: *The Robot Tortoise.* Source: P. de Latil

IN THEIR COUNTRY HOME NEAR BRISTOL, THESE PARENTS HAVE TWO CHILDREN: ONE IS ELECTRONIC.

Vivian Dovey and Grey Walter have two offspring: Timothy, a human baby and Elsie, the tortoise, of coils and electronic valves. Timothy is very friendly with his mechanized sister.

Of course, we have been doing that sort of thing forever—think of the use of natural power sources: the horse pulling a barge, a stream driving a mill. But that is hardly our paradigm for thinking about technoscientific design today, and it is certainly not how we usually think about robots, computing and intelligence. That is why Hertz's work strikes me, at least, as profoundly *strange*. And I could rephrase this strangeness as a *denaturalisation* of the Modern paradigm itself. In relation to Hertz' biological computing, the long and arduous conventional history of science and technology, industry and warfare, leading up to mainstream contemporary robotics looks like a massive *detour*—penetrating, knowing and rearranging matter at vast expense of money and effort. Hertz' robots show that there is another and much simpler way to achieve comparable ends without the detour. We can see two different *stances towards matter* in play here: the conventional one that involves penetrating black boxes through knowledge, and the cybernetic one that seeks to entrain boxes that remain black into our world. And we could understand this contrast ontologically and epistemologically. Cybernetics centres itself on a world of performative black boxes and their interrelations, whereas the Modern paradigm emphasises an intrinsically cognitive relation to matter.

Hertz' work is very interesting and it leads in nicely to what I want to discuss. Now I want to go back to the more or less forgotten origins of biological computing.

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My God, I'm a cybernetician! –Stafford Beer[6]

[6] Beer, S. *The Falcondale Collection: Stafford Beer Initiates an Audience into the World of Systems and Managerial Cybernetics.* Videotapes and transcript (Liverpool: JMU Services Ltd, 1994a).

I need to begin with some general history of cybernetics. I am especially interested in British cybernetics, and although the standard story locates the origins of cybernetics in Norbert Wiener's military research in WWII, British cybernetics (and, indeed, much of American cybernetics) began as a *science of the brain*, in which the brain was approached from a distinctive angle. As Ross Ashby, one of the British pioneers wrote in 1948: 'To some, the critical test of whether a machine is or is not a 'brain' would be whether it can or cannot 'think.' But to the biologist the brain is not a thinking machine, it is an *acting* machine; it gets information and then it

[7] Ashby, W. R. 'Design for a Brain,' *Electronic Engineering*, 20 (Dec 1948), 379-83 (379).

does something about it'.[7] Something of the strangeness of cybernetics becomes clear here. We usually think of the brain as a *representational*, cognitive device which we use for thinking. This is the view at the heart of 20th-century philosophy of science and of postwar research in artificial intelligence. And the point to grasp is that cybernetics did not approach the brain from that angle; it did not conceive the brain as primarily a cognitive organ. The cyberneticians thought of it instead as *performative*, an organ that does something, that acts—as an active and engaged switchboard between our sensory inputs from the environment and our motor organs. And beyond that, cybernetics was interested in the brain as the organ par excellence of *adaptation*, especially of adaptation to environments that had never been encountered before.

Where did cybernetics take this idea? A further defining attribute of early cybernetics was the attempt to understand the performative and adaptive brain by building electromechanical models that could mimic its performance. This was Grey Walter's rationale for constructing his robot tortoises. Like Hertz' roach-robots today, these were adaptive inasmuch as they could discover and explore environments they had never encoun-

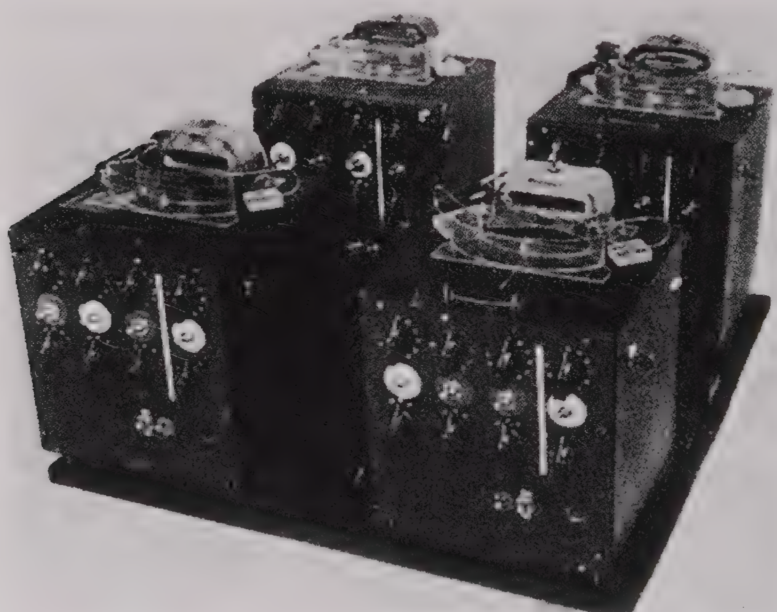

Figure 3: *The Homeostat*. Source: W. R. Ashby.

tered before without ever constructing any inner representation of their worlds. But here we need to focus on Ashby's notion of adaptation rather than Walter's, beginning with the biological notion of *homeostasis*.

Homeostasis refers to the ability of mammals to keep certain essential variables within narrow limits, independent of fluctuations in their environment—the constancy of blood temperature is an obvious example. Here one thinks of the feedback systems and servomechanisms that were themselves key referents for early cybernetics: the thermostat, for instance, that senses the temperature in a room and turns the heating up or down accordingly. One can say that the thermostat maintains the temperature in a state of *dynamic equilibrium*, tilting it one way if it tends to move in the other. Ashby thought of the body as having a whole array of such homeostatic mechanisms hard-wired into it by the genes. But he argued that we could not be hard-wired to deal with all possible fluctuations; we also have to be able to *learn* about environments we have not encountered before, and such learning was Ashby's paradigm of adaptation.

The brain was, in this sense, the supreme organ of adaptation, and to explore the mechanism of adaptation Ashby also built a machine in the late 1940s—his famous homeostat, which formed the centerpiece of his 1952 book, *Design for a Brain*, on which I can comment briefly. First, the name homeostat is misleading. The homeostat did not simply mimic a thermostat by maintaining some essential variable constant. Instead, it *became* a thermostat—a servomechanism—by randomly reconfiguring its wiring whenever it encountered environments with which it could not maintain dynamic equilibrium. Relays would trip when the current passing through it exceeded preset limits, changing the resistance and reversing the polarity of its circuits until it regained a thermostat-like relation to the environment. This *becoming-thermostat*, as Deleuze and Guattari [8] might say, was the homeostat's key property, the property that qualified it, in Ashby's opinion, as a model of the adaptive brain. And, again, we should note that the homeostat was a performative rather than a representational device. Like Walter's tortoises, the homeostat contained no inner representations of its world; it *acted*, in a double sense: it transformed inputs into outputs, and it transformed itself in pursuit of equilibrium between inputs and its outputs.

[8] Deleuze, G. and Guattari, F. *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 1987).

From the homeostat the history of cybernetics proceeded in several directions. One was Ashby's visionary attempt to develop giant artificial homeostat-like brains.[9] But we can go in another direction today. We could see Ashby's construction of the homeostat as a classically scientific detour away from the living brain in pursuit of a representational understanding. And the key to understanding Beer and Pask's work in biological computing is to see that it *undid this detour*. If a primitive adaptive system like the homeostat could be thought of as a model brain, well, the world is already full of much more sophisticated adaptive systems than the homeostat, which could function as much more sophisticated brains—perhaps even more sophisticated, in certain ways, than our own.

[9] At various times throughout the 1950s Ashby attempted to develop a more sophisticated synthetic brain called DAMS, for Distributed And Multistable System. This project did not, in the end, get far, though it is perhaps being taken up again just now. See the link at www.ibspan.waw.pl/ICANN-2005/workshops.html to the 'Building a Brain' workshop: www.ibspan.waw.pl/ICANN-2005/CreatingABrain.pdf. I am grateful to Peter Asaro for bringing this meeting to my attention.

This line of thought was most clearly laid out in a paper entitled 'Towards the Automatic Factory' that Beer presented to a symposium on self-organisation, held at the University of Illinois in June 1960.[10] Beer opened with a discussion of the concept of an 'automatic factory,' then attracting great interest, especially in the US (see Noble 1986). This was a vision of industrial automation taken, one might think, to the limit. In the automatic factory, not only would individual machines and productive operations be performed by machines without human interference, but materials would be automatically routed from one operation to the next. In the 'lights out' factory, as it was also called, the entire production process would be conducted by machines, and human labour made redundant.

[10] Beer, S. (1962a) 'Towards the Automatic Factory,' in H. von Foerster and G. Zopf (eds), *Principles of Self-Organization: Transactions of the University of Illinois Symposium on Self-Organization*, Robert Allerton Park, 8 and 9 June, 1961 [sic: actually 1960] (New York: Pergamon), pp. 25-89. Reprinted in Beer, *How Many Grapes Went into the Wine? Stafford Beer on the Art and Science of Holistic Management* (New York: Wiley, 1994), pp. 163-225.

Beer was not in 1960 a critic of the automatic factory, except that he felt that current conceptions were not automatic enough. He compared them to a 'spinal dog'—a dog whose nervous system had been surgically disconnected from the higher levels of its brain. The automatic factory:

> has a certain internal cohesion, and reflex faculties at the least. [But] When automation has finished its work, the analogy may be pursued in the pathology of the organism. For machines with over-sensitive feedback begin to 'hunt'—or develop ataxia; and the whole organism may be so specialized towards a particular environment that it ceases to be adaptive: a radical change in the market will lead to its extinction.[11]

[11] Beer, S. 'Towards the Automatic Factory' Reprinted in Beer, *How Many Grapes Went into the Wine? Stafford Beer on the Art and Science of Holistic Management* (New York: Wiley, 1994 [1962a]), pp. 163-225 (164).

Beer's argument was that to make it adaptive and to avoid extinction in market fluctuations, the automatic factory would need a brain.

> At present, such an automatic factory must rely on the few men left at the top to supply the functions of a cerebrum. And . . . the whole organism is a strange one—for its brain is connected to the rest of its central nervous system at discrete intervals of time by the most tenuous of connections. The survival-value of such a creature does not appear to be high . . . This will not do. The spinal dog is short of a built-in cerebrum; and the automatic factory is short of a built-in brain. The research discussed in this paper is directed towards the creation of a brain artefact capable of running the company under the evolutionary criterion of survival. If this could be achieved, management would be freed for tasks of eugenics; for hastening or retarding the natural processes of growth and change, and for determining the deliberate creation or extinction of whole species.[12]

[12] Ibid, p. 165.

The cybernetic factory, as Beer imagined it, would be *viable*—a key term for him: it would react to changing circumstances, it would grow and evolve like an organism or species, all without any human intervention at all.

Figure 5 is a schematic of Beer's cybernetic factory, and for present purposes the key element to think about is the box marked 'homeostat loop' at the bottom centre, which Beer elsewhere referred to as the 'U-machine. This sits like a spider in a mesh of information flows—inputs reflecting the state of the factory and its environment, and outputs that determined its parameters. The U-machine was the brain of Beer's imagined automatic factory. The question was then, just what should the U-machine be? Beer remarked that:

> As a constructor of machines man has become accustomed to regard his materials as inert lumps of matter which have to be fashioned and assembled to make a useful system. He does not normally think first of materials as having an intrinsically high variety which has to be constrained. . . [But] We do not want a lot of bits and pieces which we have got to put together. Because once we settle for [that], we have got to have a blueprint. We have got to design the damn thing; and that is just what we do not want to do.[13]

[13] Ibid, pp. 209, 215.

This critique of design is a striking index of the difference between cybernetics and Modern technoscience. Intrinsic to the latter is a principled rearrangement of otherwise passive matter to bend it to our will;

but this was what Beer proposed not to do. Along the same lines, he also talked about 'new developments in solid state physics,' for which he had nothing but admiration, but he argued that 'I am unable to see how "design" can be eliminated from molecular electronics.' One has to specify the configuration of a chip, say, before one can build it, and this is an impediment to the construction of a U-Machine that could continually reconfigure itself. To be adaptable, the machine would have to know its own design, work variations on that, and then reconstruct itself. And, of course, the 'techniques so far available . . . involve massive equipment that could hardly be visualized as operated by the U-Machine to change its own internal mechanism'.[14] [15]

[14] Ibid, p. 210.

[15] 'Beer: And the other big point I would like to make, about the big electronic machines, which I think are just dinosaurs . . ./Bowman: Subject to the same fate?/Beer: I think so' (Beer 1962a, 220).

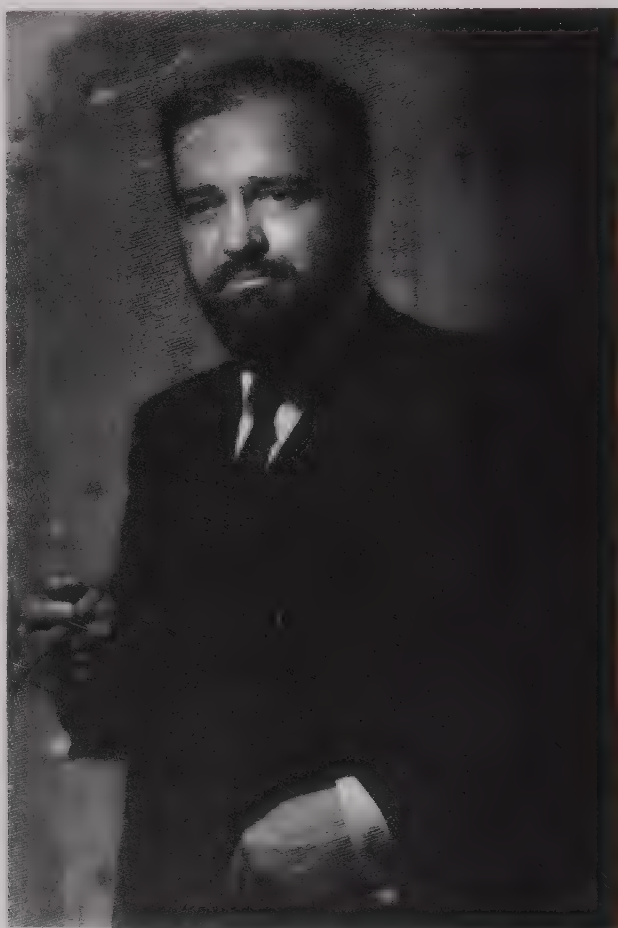

Figure 4: Beer in the 1960s. Source: S. Beer.

Nevertheless, said Beer in 1960, 'Before long a decision will be taken as to which fabric to use in the first attempt to build a U-Machine in actual hardware (or colloid, or protein)'.[16] Colloid or protein? This gets us back to biological computing and the adaptive brain. Beer's idea was simply—if one can say that—to enroll some naturally occurring adaptive system as the U-machine, as the brain of a totally automatic adaptive factory. During the second half of the 1950s, he had, in fact, embarked on what he described as 'an almost unbounded survey of naturally occurring systems in search of materials for the construction of cybernetic machines'[17] and in 1962 he published a brief and, alas, terminal report on the state of the art, which makes fairly mind-boggling reading.[18] We can glance at some of the systems he discussed there to get a flavour of this work.

Beer's list of candidates for the U-machine begins with quasi-organic electrochemical systems, but I want to postpone discussion of these for a while. Then comes Beer's successful attempt to use positive and negative feedback to train young children (presumably his own) to solve simultaneous equations *without* teaching them the relevant mathematics—to turn the children into a performative (rather than cognitive) mathematical machine. Beer then moves on to discuss various thought-experiments involving animals:

> Some effort was made to devise a 'mouse' language which would enable mice to play this game—with cheese as a reward function . . . In this way I was led to consider various kinds of animal, and various kinds of language (by which I mean inter-communicating boxes, ladders, see-saws, cages connected by pulleys and so forth). Rats and pigeons have both been studied for their learning abilities . . . The Machina Speculatrix of Grey Walter might also be considered (with apologies to the organic molecule) . . . However no actual machines were built. . . By the same token, bees, ants, termites, have all been systematically considered as components of self-organizing systems, and various 'brain-storming' machines have been designed by both Pask and myself. But again none has been made.[19]

Here, I would guess, we are at the origin of the mouse-computer that turns up in both Douglas Adams' *Hitch-Hikers Guide to the Galaxy* and Terry Pratchett's *Discworld* series of fantasy novels.[20] The most convincing fictional representations of biological computing that I have come across are

[16] Beer, S. 'Retrospect—American Diary, 1960,' in Beer, *How Many Grapes Went into the Wine? Stafford Beer on the Art and Science of Holistic Management* (New York: Wiley, 1994), pp. 229-309.

[17] Beer. S. *Cybernetics and Management* (London: English Universities Press, 1959), p. 162.

[18] Beer, S. 'A Progress Note on Research into a Cybernetic Analogue of Fabric,' Artorga, Communication 40, April 1962. Reprinted in Beer, *How Many Grapes Went into the Wine? Stafford Beer on the Art and Science of Holistic Management* (New York: Wiley, 1994 [1962b]), pp. 24-32.

[19] Ibid, pp. 28-29.

[20] In the *Hitch-hiker's Guide*, the earth is a giant analogue computer built by mice-like beings to answer (or was it discover?) the Ultimate Question. On the earth as an analogue computer, see also Blohm, Beer and Suzuki (1986).

[21] Bear, G. *Slant* (New York: Tor, 1997).

the visibly organic control systems of alien space ships that featured in various episodes of *Dr Who* and, more recently, in Greg Bear's novel, *Slant*,[21] which includes, as I recall, colonies of beans and wasps.

Beer had, however, devoted most of his own efforts to systems composed from simpler organisms: colonies of *Daphnia*, a freshwater crustacean (Pask had considered mosquito larvae), of *Euglena* protozoa, and an entire pond ecosystem (Figure 6):

> [P]ure cultures . . . are not, perhaps, ecologically stable systems. Dr. Gilbert, who had been trying to improve the *Euglena* cultures, suggested a potent thought. Why not use an entire ecological system, such as a pond? . . . Accordingly, over the past year, I have been conducting experiments with a large tank or pond. The contents of the tank were randomly sampled from ponds in Derbyshire and Surrey. Currently there are a few of the usual creatures visible to the naked eye (*Hydra*, *Cyclops*, *Daphnia*, and a leech); microscopically there is the expected multitude of micro-organisms. The state of this research at the moment is that I tinker with this tank from time to time in the middle of the night.

Some clarification might be needed here. The key point is that all the systems Beer talked about are adaptive systems, capable of reconfiguring themselves in the face of environmental transformations. In a steady state, an ecosystem like a pond, for example, exists in a state of dynamic equilibrium with its environment, homeostatically responding to fluctuations that threaten its viability, and if the environment changes, the ecosystem will reconfigure itself to achieve a dynamic equilibrium with that, just like Ashby's electromechanical homeostats. Beer's idea was that if one could only couple such an adaptive system to a factory, say, making the factory part of the pond's environment, and vice versa, the health of each could be made to hinge on that of the other, in a process that Beer called *reciprocal vetoing*. Disturbances from the factory might trip the ecosystem into a new configuration, which would in turn perturb the operation of the factory, and if the factory in its new state was still unstable, new disturbances would travel back to the ecosystem—and so on until the pond and the factory achieved a collective state of dynamic equilibrium with each other and their outside environments. This is the way in which a pond with some small organisms and a leech could serve

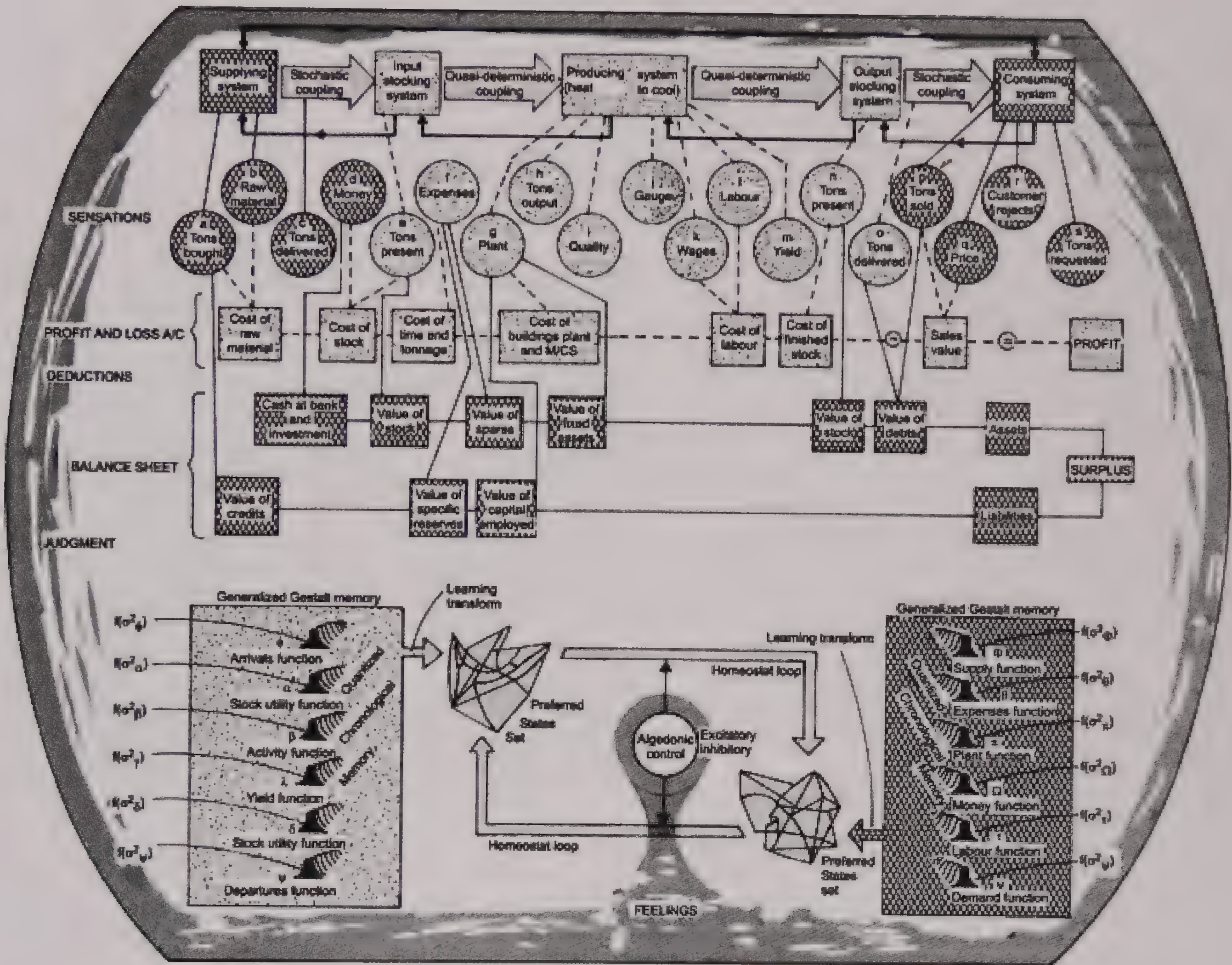

Figure 5: *The Cybernetic Factory*. Source: S. Beer.

as an adaptive brain for the automatic factory. An amazing idea, though I can see no reason in principle why it should not work.

Having said that, of course, there are not, at the moment, any such biological computers. As I hinted already, this project came to naught. The immediate technological problem lay in achieving a coupling between naturally adaptive systems and the systems they were

MAVERICK MACHINES/143

A real-life modular processor? Every element in this pond – weeds, algae, bacteria – is in some sense independent, but also controlled by day length, temperature and rainfall.

Figure 6: Maverick Machines: Pond as Biological Computer.
Source: G. Pask with S. Curran.

intended to control. From the schematic of the automatic factory it is clear that Beer had analysed what the key input and output variables were. The problem was to make biological systems *care about them.* How could they be translated into variables that would impinge significantly on a biological controller? In his 1962 review Beer mentioned a couple of attempts to do this, and indicated where difficulties had arisen:

> Many experiments were made with [Daphnia]. Iron filings were included with dead leaves in the tank of Daphnia, which ingested sufficient of the former to respond to a magnetic field. Attempts were made to feed inputs to the colony of Daphnia by transducing environmental variables into electromagnets, while the

outputs were the consequential changes in the electrical characteristics of the phase space produced by the adaptive behaviour of the colony. . . However, there were many experimental problems. The most serious of these was the collapse of any incipient organization—apparently due to the steadily increasing suspension of tiny permanent magnets in the water.[22]

[22] Beer, S. 'A Progress Note on Research into a Cybernetic Analogue of Fabric', (New York: Wiley, 1994 [1962b), pp. 24-32 (29).

To put it another way, having consumed the iron filings, the *Daphnia* excreted them and the water filled with rust. Another attempt hinged on the fact that *Euglena* are sensitive to light, and Beer sought to achieve optical couplings to a tank full of them. 'However, the culturing difficulties proved enormous. *Euglena* showed a distressing tendency to lie doggo, and attempts to isolate a more motile strain failed.'

The collapse of Beer and Pask's biological computing project in the early 1960s did not then imply any inherently fatal flaw in its conception. We should not refuse to entertain this strange nonModern paradigm on that ground. The primary obstacle lay in getting adaptive biological systems to engage with us, in finding some practical means of signaling to them in ways that they might respond to. And here, the opening sentences of Beer's 1962 review bears attention: 'Everything that follows is very much a spare time activity for me, although I am doing my best to keep the work alive—for I have a conviction that it will ultimately pay off. Ideally, an endowed project is required to finance my company's Cybernetic Research Unit in this fundamental work'.[23]

[23] Ibid, p. 25.

I quoted Beer above on tinkering with tanks in the middle of the night, evidently at home, and his daughter, Vanilla, has fond childhood memories of weekend walks with her father to collect water from local ponds. And here we run into an absolutely typical sociological feature of British cybernetics: key developments were achieved on an amateur basis, outside all of the usual institutions of support. Beer did his work on biological computing on his own time, for fun, while running what was probably the world's biggest industrial OR group for a living. Obviously one can connect the strangeness of cybernetics to the lack of an institutional base—these two features hung together and reinforced one another—but it would take another essay to develop that thought further.[24] I just want to note that (1) given this hobby-ist social basis, it

[24] Pickering, A. '*Cybernetics as Nomad Science*,' Annual Meeting of the Society for Literature, Science, and the Arts, Chicago, 10-13 November 2005b.

is not surprising that many of the most interesting cybernetic innovations languished after the 1960s, and that (2) some of them *are* now resurgent, as, for example, Garnet Hertz' roach-controlled robots, though (3) projects like Beer's in the 60s were much more ambitious than latter-day versions, especially in that (4) sophisticated notions of adaptation running from Ashby to Beer and Pask have got lost along the way to the present. And to elaborate that last thought, I promised to return to the first item on Beer's 1962 list, quasi-organic electrochemical computers. Beer and Pask worked on these together and separately, but they are most extensively discussed in several long publications in the late 1950s and early 1960s from Gordon Pask, so the next section is about Pask's work.[25]

[25] Pask's publication list begins with 18 papers written between 1957 and the publication of *An Approach to Cybernetics* in 1961. Ten are about teaching machines; the other eight are about cybernetic controllers such as chemical computers.

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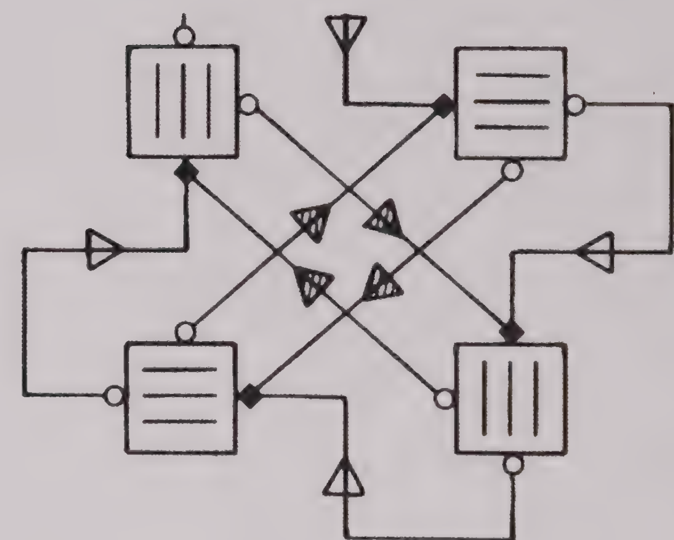

Effects of *Euglena* upon each other. ☰, ***Euglena*** **culture, with tropism displayed as shown; ◆, stimulus; ○, sensory receptor; ◬, inhibiting and △, stimulating influence of a's sensation on b's stimulus**

Figure 7: The Euglena Homeostat. Source: S. Beer.

> Self-organizing systems lie all around us. There are quagmires, the fish in the sea, or intractable systems like clouds. Surely we can make these work things out for us, act as our control mechanisms, or perhaps most important of all, we can couple these seemingly uncontrollable entities together so that they can control each other. Why not, for example, couple the traffic chaos in Chicago to the traffic chaos of New York in order to obtain an acceptably self-organizing whole? Why not associate individual brains to achieve a group intelligence?[26]

[26] Pask, G. 'The Natural History of Networks,' in M. Yovits and S. Cameron (eds), *Self-Organizing Systems: Proceedings of an Interdisciplinary Conference*, 5 and 6 May (New York: Pergamon, 1960), pp. 232-63 (258).

Figure 9 is a schematic of one of Pask's devices. A set of electrodes dips down vertically into a dish of ferrous sulphate solution. As current is passed through the electrodes, filaments of iron—'threads' as Pask called them—grow outwards from their tips into the liquid: Figure 10 is a photograph of a stage in this process. Very simple, but so what? Three points need to be understood. First, the threads are *unstable*: they grow in regions of high current density but dissolve back into solution otherwise. Second, the threads grow *unpredictably*, sprouting new dendritic branches (which might extend further or dissolve). We can thus see how such a system might be seen as conducting a search through an open-ended space of possibilities, and we can also see that it has the *high variety*—another cybernetic term of art—required of a controller. Third, as extensions of the electrodes, the threads themselves influence current densities in the dish. Thus the present thread-structure helps determine how that structure will grow as a function of the currents flowing through the electrodes, and hence the growth of the thread-structure exhibits a path-dependence in time: it depends in detail on both the history of inputs through the electrodes and on the emerging responses of the system to those. The system thus has a *memory*, so it can *learn*. This was Pask's idea: the chemical computer could function as an adaptive controller, in the lineage of the homeostat.

The question now becomes one of how such a system might be interested in us: how can a chemical computer be induced to substitute for the human manager of a factory, for example? As with Beer's biological computers, the answer is simple enough, at least in principle. Imagine there are two different sets of electrodes dipping into the dish of ferrous sulphate with its thread structure. One set are inputs:

the currents flowing through them reflect the parameters of the factory (orders, stocks, cash-flow, etc). The other set are outputs: the voltages represent instructions to the factory (buy more raw materials, redirect production flows). There will be some determinate relationship between these inputs and outputs, fixed by the current thread-structure, but this structure will itself evolve in action and, as Ashby would have said, the combined system of factory plus controller will inevitably 'run to equilibrium.' Like a set of interacting homeostats, the chemical computer and the factory will eventually find some operating condition in which both remain stable: the factory settles down as a viable system, in Beer's terms, and the chemical computer, too, settles down into a state of dynamic equilibrium (until some uncontrollable perturbation arrives, when the search process starts again).

The magic is done—almost. Let me make one comment before I go on with the story. I need to refine my sense of biological computing as avoiding the Modern detour away from the world. Even when we talked about Beer and ponds, some detour away from nature-as-found was required—literally: Beer had to wander down to the nearest pond with a bucket to collect water and organisms and take them home again. In the case of Pask's organic computers, the detour is more obvious. One does not find electrolytic cells lying around in nature; they have to be made. So this sort of cybernetic engineering does entail a detour. But I still want to note three points of contrast with the Modern paradigm. First, the cybernetic detour is noticeably shorter than those typical of Modern technoscience. Filling a bucket in a pond or setting up an electrolytic cell are immeasurably simpler operations than setting up a semiconductor industry. Second, and very importantly, biological computing *did not involve the same sort of detour* through knowledge as electronic computing. As I said earlier, all that Pask and Beer needed to know about their systems was that they were adaptive black boxes; there was no equivalent here of the knowledge of inner workings that characterises the modern sciences. And third, the other side of that, these black boxes were immediately performative devices: they did not themselves produce knowledge—unlike electronic computers with their representational inner states, for example, they acted, rather than thought. So I

Figure 8: Gordon Pask. Source: Amanda Heitler.

want to stress that even when these nuances are added, the contrast between biological computing and the Modern paradigm remains. Now back to the story.

Pask thought through at least two further aspects of biological computing. First, there was the question of how to get the process of coupling the computer into human affairs going. How should the threads begin to learn about running a factory? One answer was to envisage a 'catalyst,' a system that would send current through the 'least visited' electrodes, thus fostering a variety of interactions with the factory and enabling the computer to interrogate the factory's performance on a broad front. Of course, second, the procedure of simply letting the computer and the factory search open-endedly for a mutual equilibrium would almost certainly be disastrous. Who knows what idiotic instructions the computer would issue to the factory before stability was approached, or how quickly the factory would wreck the computer?

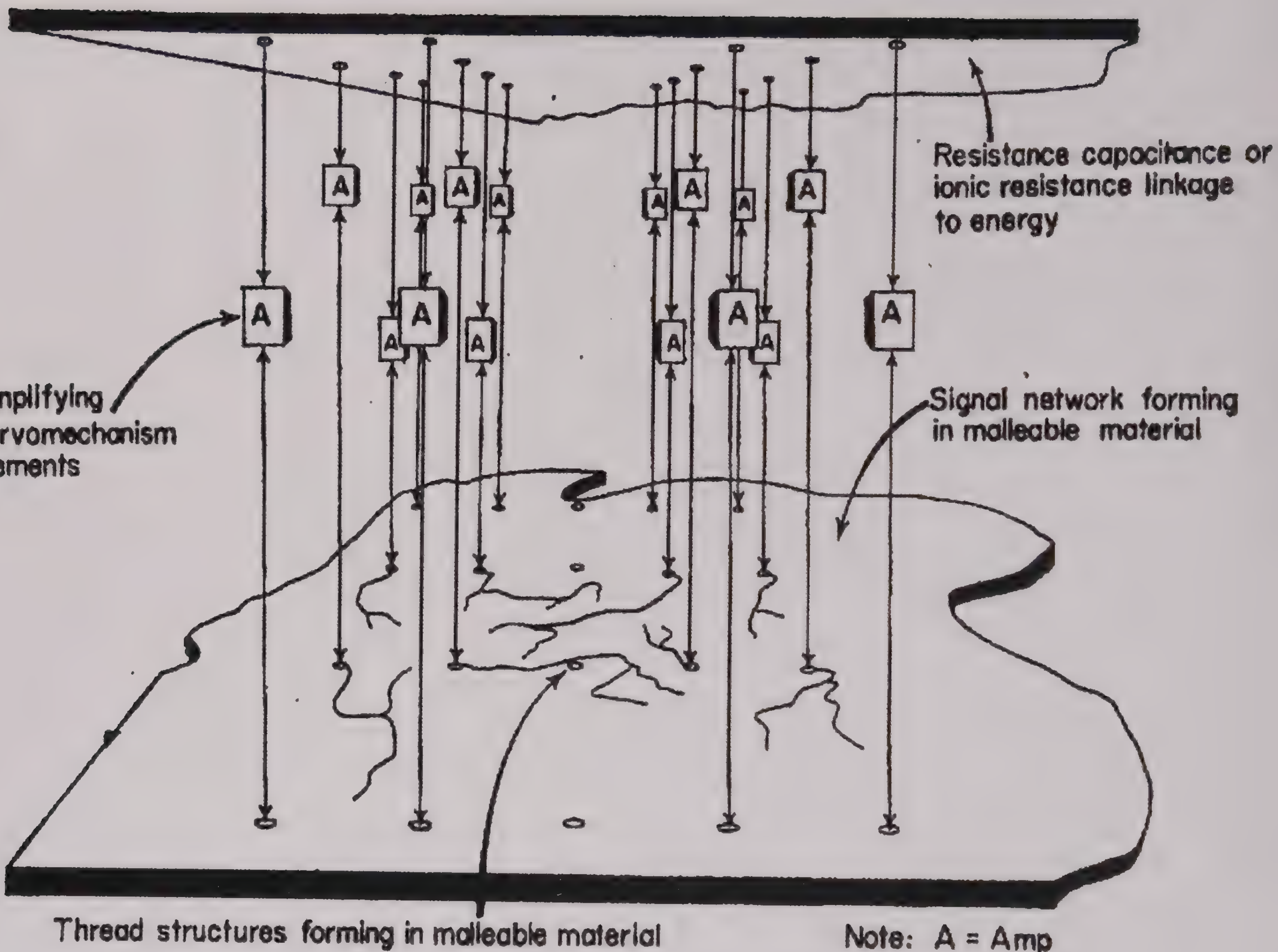

Figure 9: *Schematic of a Chemical Computer*. Source: G. Pask.

Pask therefore imagined that a human manager would be allowed to *train* the controller, monitoring the state of the factory and the machine's responses to that, and approving or disapproving those responses by injecting pulses of current as appropriate to reinforce positive tendencies in the machine's evolution, as indicated in Figure 11. Pask noted that this kind of training would *not* take the form of the manager dominating the controller and dictating its performance; there was no way that could be done. In fact, the interaction would have to take the form of a 'partly competitive and partly collaborative game . . . after an interval, the structured regions [in the controller] will produce a pattern of behaviour which the manager accepts, not necessarily one he would have approved of initially, but one he accepts as a compromise.' Thus the manager and the controller come into homeostatic equilibrium with one another at the same time, in the same way, and in the same process as the controller comes into equilibrium with the factory. 'At this point the structured region will replicate indefinitely so that its replica produces the same pattern of behaviour. The manager may thus be removed and the assemblage will act as an organic control mechanism in the industry'.[27]

[27] Pask, G. 'Organic Control and the Cybernetic Method,' *Cybernetica*, 1, (1958) 155-73

My comment now is that here we have a contrast between the nonModern and Modern paradigms that I have not mentioned before. In the Modern paradigm, the impulse is to bend nature to our will. If a digital computer does not execute the operations we envisage for it, something has gone wrong. Biological computing entailed a much more *symmetric* relation between the human and the nonhuman—a 'conversation,' as Pask put it, a 'compromise,' in which human performances and goals, the specifics of management, were themselves liable to open-ended transformation—mangling[28]—in negotiation with ponds or electrolytic cells, performative black boxes. Now I should complete the story of Pask's devices.[29]

[28] Pickering, A. *The Mangle of Practice: Time, Agency, and Science* (Chicago: University of Chicago Press, 1995).

[29] What follows is indebted to an essay by Peter Cariani (1993) which first rescued key aspects of Pask's work from obscurity, and I am very grateful to Cariani for fascinating discussions around the topics at issue.

I have emphasised that biological computers remained Black Boxes in their inner workings, but a field of knowledge did enter into their construction in relation to their couplings. In Beer's 1960 vision of the automatic factory, the input and output channels to the U-machine were specified by the designer, Beer himself. Which variables in the factory the U-machine should pay attention to, and which variables it should act on, were hard-wired into the system—as if the brain's sensory and effector channels were fixed forever in advance. There is nothing surprising about this to the Modern imagination—it seems one of the more unremarkable features of Beer's vision. But Beer and Pask wanted to go further. Pask imagined a situation in which a transformation in production methods upset Bill Smith, the foreman, whose happiness then turned out to be crucial to the smooth running of the entire factory. In Pask's scenario, the human manager notices this, and switches some of the production to a project that makes no profit in itself but keeps Bill happy. Could one imagine a biological computer adaptive enough to pick up on new variables that had not been specific in advance—a device which could develop new senses, so to speak?

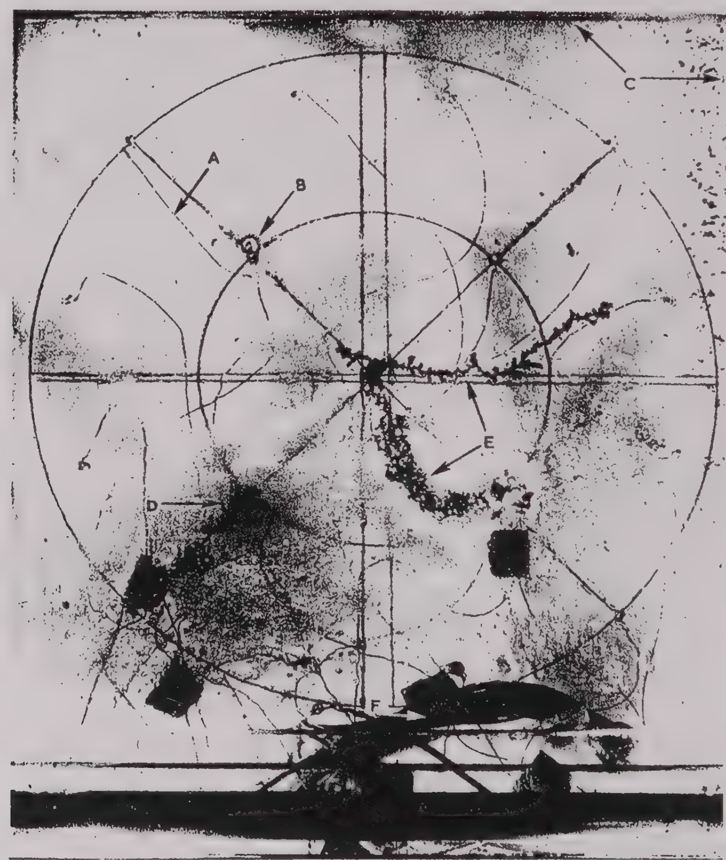

Fig.12. (A) Connecting wires for electrodes.
(B) Platinum pillar electrodes.
(C) Edges of glass tank containing ferrous sulphate.
(D) Chemical reaction in progress
(E) "Tree" threads being formed.
(F) Connecting cables.

Figure 10: *Threads Growing in a Chemical Computer.* Source: G. Pask.

In a 2001 festschrift for Pask, Beer recalled that in 1956 or 1957 he was visiting London from Sheffield, and spent most of the night with Pask at the latter's flat in Baker Street, as he often did. They first had the idea of exploring the robustness of Pask's chemical computers by chiseling out sections of established threads and seeing what happened. It turned out that the systems were very robust—another contrast with Modern computing. 'And yet these demonstrations, though exciting at the time, were somehow recognized to be trivial' [30]:

> 'Adaptation to the unexpected' should mean more than this, and yet there must be limits. I was already developing my theory of viable systems, and often used myself as an example. But what if someone pulled out a gun and shot me. Would that be proof that I am not after all a viable system? Surely not . . . Suddenly Gordon said something like, 'Suppose that it were a survival requirement that this thing should learn to respond to sound? If there were no way in which this [sound] 'meant' anything [to the device], it would be equivalent to your being shot. . . We need to see whether the cell can learn to reinforce successfully by responding to the volume of the sound.' It sounded like an ideal critical experiment. I cannot remember what exactly the reinforcement arrangements were, but the cell already had them in place . . . [31] And so it was that two very tired young men trailed a microphone down into Baker Street from the upstairs window, and picked up the random noise of dawn traffic in the street. I was leaning out of the window, while Gordon studied the cell. 'It's growing an ear,' he said solemnly . . . A few years later Gordon was to write:[32]
>
> We have made an ear and we have made a magnetic receptor. The ear can discriminate two frequencies, one of the order of fifty cycles per second and the other of the order of one hundred cycles per second. The 'training' procedure takes approximately half a day and once having got the ability to recognize sound at all, the ability to recognize and discriminate two sounds comes more rapidly . . . The ear, incidentally, looks rather like an ear. It is a gap in the thread structure in which you have fibrils which resonate at the excitation frequency.

There is something truly remarkable about this episode. I can think of no equivalent in the history of Modern science and technology. As Beer put it in 2001, 'It could well have been the first device ever to do this [develop a new sense], and no-one has ever mentioned another

[30] Beer, S. 'A Filigree Friendship,' *Kybernetes*, 30, (2001) 551-59 (554-55).

[31] As usual, Pask was himself not very forthcoming on the practical details. Pask (1958, 166-67) sketches out a means for monitoring the development of threads in some region using four ancillary electrodes. Two electrodes emit current periodically (presumably to inhibit growth of threads from them) and the others register some response. The trick would be to look for changes in response correlated with sounds in the required range (as detected by a filter attached to the microphone). Positive correlations could then be encouraged by injecting more current into the assemblage as they occur.

[32] Pask, G. 'The Natural History of Networks' (New York: Pergamon, 1960), pp. 232-63 (261).

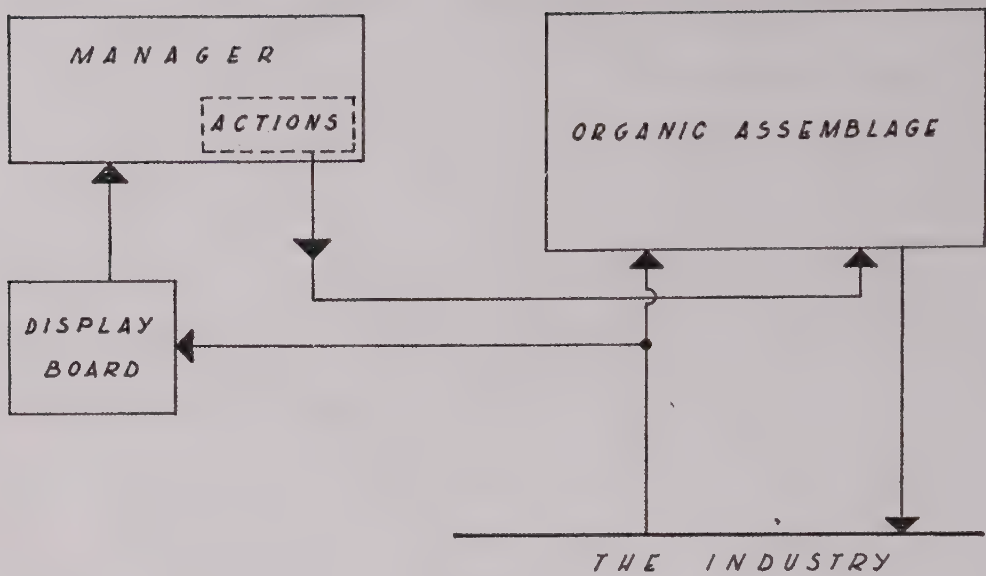

Figure 11: *Training a Chemical Computer* (image: G. Pask).

in my hearing'.[33] [34] It is common enough in the history of electronic computing to add senses to a machine—Grey Walter made it possible for his tortoises to hear by wiring a microphone into their circuits—but this has always been by design, something imposed from the outside by the designer. Beer and Pask, in contrast, simply exploited the inner agency of their adaptive Black Box—a possibility which I think could not even be imagined in the Modern paradigm. One way to see what is at stake here would be to say that the Modern detour through knowledge and away from the world can also be *a block*, a trip that forecloses options that Beer and Pask's work demonstrates lie actually already at hand. Perhaps we are more impressed by this technoscientific trip than we should be.[35]

***

We have come to the end of the technical history of biological computing, apart from the very recent and rudimentary re-awakening that we began with. In the 1960s, both Beer and Pask developed their cybernetics in new directions. In management, Beer articulated his Viable System Model, in which organisational structures and information flows aimed to emulate the adaptive qualities of the human brain and nervous system. Pask focused on the development of interactive and conversa-

[33] Beer, S. 'A Filigree Friendship,' (2001) p. 555.

[34] The question of how we would recognise a new sense if we came across one arises here: see Cariani (1993).

[35] I have been seeking to clarify the ontological contrast between Beer and Pask's biological computers and their Modern counterparts, but Pask also discussed in very interesting ways the epistemological difference between Modern science and cybernetics (for example, Pask 1958, 172-73). He understood the former as having a distanced and intrinsically representational relation to matter going through the experimental testing of pre-given hypotheses. Cybernetics, in contrast, was about establishing productive and performative relations via open-ended and intimate engagements, from which behavioural knowledge was an output.

tional teaching machines, as well as making very imaginative contributions in the theatre, architecture and robotic art.[36] But to stay with my topic a little longer, I will end with a discussion of what one might call the spirituality of biological computing.

[36] Pickering, A. 'Cybernetics and the Mangle: Ashby, Beer and Pask,' *Social Studies of Science*, 32, (2002) 413-37.

In Modernity, science and spirituality have nothing to do with one another. It is part of the Modern Constitution, as Bruno Latour[37] calls it, that they inhabit disjointed ontological realms. It is just another aspect of cybernetics' nonModernity that it tended to erase that disjuncture. Beer, in particular, was profoundly religious from an early age, and ended his life as a self-described Tantric yogi, so I want here to explore some aspects of his spirituality and how they connect to his work in biological computing.

[37] Latour, B. *We Have Never Been Modern* (Cambridge, MA: Harvard University Press, 1993).

We can proceed in two stages. First, in a 1966 essay entitled 'Cybernetics and the Knowledge of God,' Beer began by pointing to the finitude of the human mind: 'Each of us has about ten thousand million neurons to work with. It is a lot, but it is *the* lot. . . [T]his means that there is a strict mathematical limit to our capacity to compute cerebrally—and therefore to our understanding. For make no mistake: understanding is mediated by the machinery in the skull'.[38] What is to be admired and wondered at, therefore, is not our knowledge of the world—or the world-as-known—but the world itself, which Beer referred to as 'an irreducible mystery: that there is anything'.[39] And, for Beer, this is where God comes in: '*God is what explains the mystery*'.[40]

[38] Beer, S. 'Cybernetics and the Knowledge of God,' *The Month*, 34, (1966) 291-303 (294).

[39] Ibid, p. 298.

[40] Ibid, p. 299.

What Beer points to in this essay is thus a sort of gestalt switch lying between Modern science and his cybernetics. If Modernity proceeds as if nature were exhaustible by knowledge, and as if God were somewhere else, Beer here expresses his suspicion of representation, as somehow veiling the spiritually-charged thing in itself from us. And in this essay he emphasised this contrast himself[41]:

[41] Ibid, pp. 294-8.

> To people reared in the good liberal tradition, man is in principle infinitely wise; he pursues knowledge to its ultimate . . . To the cybernetician, man is part of a control system. His input is grossly inadequate to the task of perceiving the universe . . . there is no question of 'ultimate' understanding. . . [I]t is part of the cultural tradition that man's language expresses his thoughts. To the cybernetician, language is a limiting code in which everything has to be expressed—more's the pity, for the code is not nearly rich enough to cope[42]. . . Will you tell me that science is going to

[42] Ibid, pp. 294-5.

> deal with this mystery [of existence] in due course? I reply that it cannot. The scientific reference frame is incompetent to provide an existence theorem for existence. The layman may believe that science will one day 'explain everything away'; the scientist himself ought to know better.[43]

[43] Ibid, p. 298.

Next, we can turn to a book Beer published in 1986 called *Pebbles to Computers*.[44] This is a nonlinear history of computing, running from simple counting to digital computers but also embracing, for example, Stonehenge as an astronomical computer and Peruvian *quipus*, beautiful knotted threads, as calculational devices. Here Beer goes beyond his awe at the sheer excess of matter over representation to emphasise an again spiritually-charged wonder at matter's *performativity* and, especially its computational performance. There are several fascinating passages on this, but to keep things short let me mention just one. Under the heading 'Nature Calculates,' Beer comments on a photograph of the Gatineau River (Figure 13) that catches the endless complexity of the water's surface:

[44] Blohm, H., S. Beer and Suzuki, D. *Pebbles to Computers: The Thread* (Toronto: Oxford University Press, 1986).

> This exquisite photograph of water in movement . . . has a very subtle message for us. It is that nature's computers are that which they compute. If one were to take intricate details of wind and tide and so on, and use them . . . as 'input' to some computer simulating water—what computer would one use, and how express the 'output'? Water itself: that answers both those questions.[45]

[45] Ibid, p. 51.

Nature does not need to make any detours; it does not just exceed our computational abilities, in effect it surpasses them in unimaginable ways. In a poem on the Irish Sea in the same book, Beer also talks about nature as doing a 'bigger sum' than ours, exceeding our capacities in way that we can only wonder at, 'shocked' and 'dumbfounded.'[46] And to emphasise the point, Beer again makes a contrast with the ontological stance of Modern Science:

[46] To inject a personal note, these words read very true to me. They remind me of my days as a postdoctoral researcher in theoretical particle physics, spending weeks and months trying and failing to understand mathematically how quarks interact, while being painfully aware that the quarks themselves were doing their own thing all the time, in real-time. throughout the cosmos (or so I believed at the time). That kind of experience leaves one with a feeling for scientific knowledge as a pale simulacrum of the world (or not even that in my case), a simulacrum one nevertheless finds it hard not to mistake for the thing in itself.

> The uneasy feeling that [this poem] may have caused derives. perhaps, from insecurity as to who is supposed to be in charge. Science (surely?) 'knows the score.' Science does the measuring after all. . . . But if art is said to imitate nature, so does science. . . Who will realize when the bathroom cistern has been filled—someone with a ruler and a button to press, or the ballcock that floats up to switch the water off? Nature is (let it be clear that) nature is in charge.[47]

[47] Blohm, H., S. Beer and Suzuki, D. *Pebbles to Computers* (Toronto: Oxford University Press, 1986), p. 53.

'Nature is in charge' is a succinct expression of what I would call Beer's hylozoism: his spiritually-charged awe at the activity and powers of nature in relation to our inability to grasp them representationally. And I can offer two comments on this. First, while it is not necessary to subscribe to Beer's hylozoism to be interested in biological computing, one can certainly see how such ontology hangs together with Beer and Pask's strange projects. If we are already and inevitably plunged into the infinite computing power of nature, the long trip through chip manufacture and digital computation certainly appears as a massive detour. Second, we can take this line of thought further. Beer's thought was that mind is everywhere, immanent in matter itself. I focused earlier on naturally occurring adaptive systems as model brains, but now we can add the Gatineau River, the Irish Sea and toilet-flushing mechanisms (all watery phenomena, interestingly). If we add the cybernetic notion that all of these mind-phenomena are reciprocally coupled to one another in a homeostatic fashion, then we move towards a conception of minds, including the human mind,

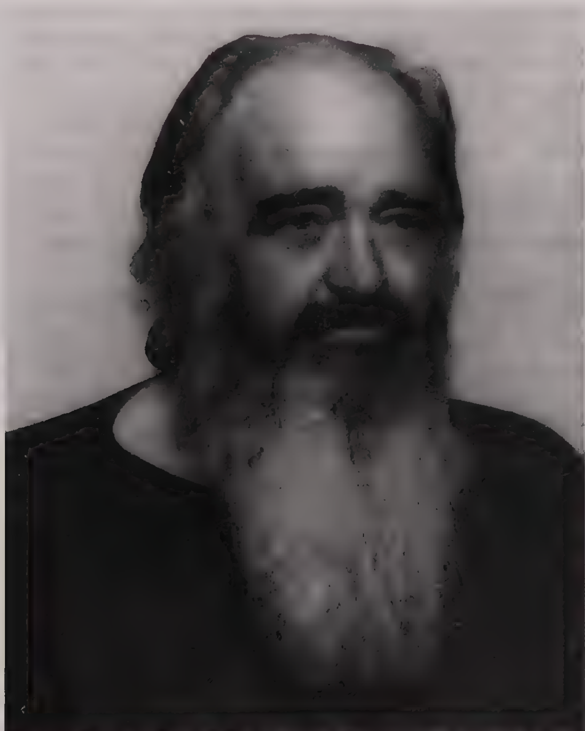

Figure 12. Stafford Beer, 1975. Source: S. Beer.

as intrinsically decentered and merging into one another. And this takes us from the starting point of this section, Beer's awe at the excess of matter, towards a Buddhist and very nonModern image of the human mind as extending beyond the Modern self in performative engagement with the nonhuman mind-stuff of the cosmos. *Pebbles to Computers* comes to an end with a quotation Beer attributes to the *hsin hsin ming* by Sengstan, the third Zen patriarch:

> Things are objects because of the mind;
> The mind is such because of things.
> Understand the relativity of these two
> and the basic reality: the unity of emptiness.
>
> In this emptiness the two are indistingushable
> and each contains in itself the whole world.[48]

[48] Ibid, (d.606)(p.105).

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I should try to sum up. What I have been trying to do is contrast a nonModern cybernetic paradigm with the Modern technoscientific paradigm that Heidegger railed against. I have tried to get this into focus by talking about Beer and Pask's strange and wonderful initiatives in biological computing. This last section of the talk helps me, at least, to get the ontological aspect of the contrast into focus better. Cybernetics placed the inexhaustible powers of nature at its centre, where Modern technoscience has representation instead. Modernity is thus characterisable by its enormous detours through knowledge and industry, while cybernetics stays close to the performative world as found, abstaining from the attempt to unwrap Black Boxes. And if Modernity is defined by projects of domination, then cybernetics is marked by a symmetric accommodation to the ultimately uncontrollable. If I developed this last point, especially as it includes our dealings with other people, it would get us into a discussion of a distinctly cybernetic politics which I find distinctly preferable to the politics of Modernity today. Finally, I outlined a spiritual stance that also differentiates cybernetics from Modernity in its hylozoist collapse of spirit and matter. Cybernetics, one might say, retains the space for wonder that Modern technoscience obscures—and that is not the least of this strange paradigm's virtues.

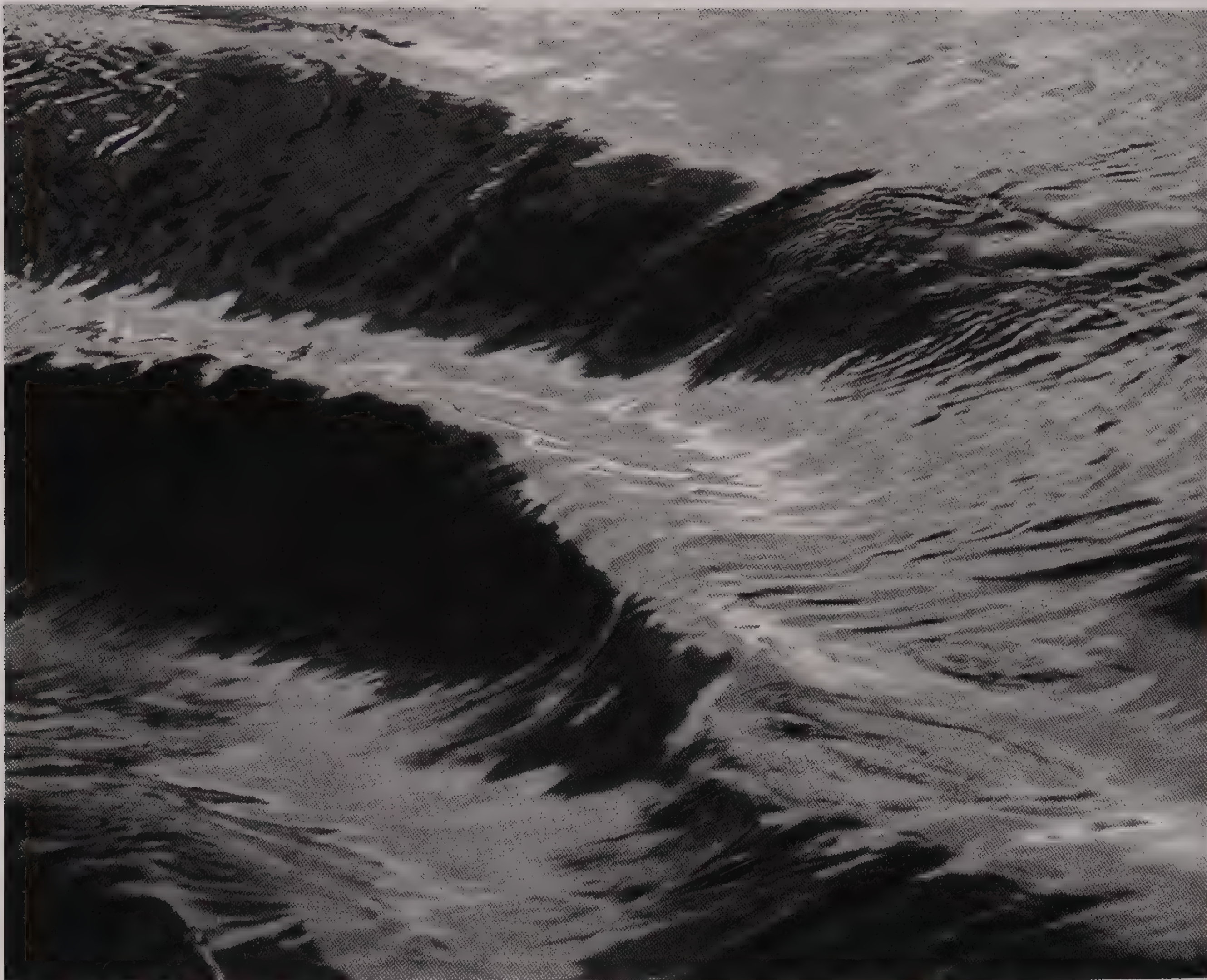
Figure 13. The Gatineau River, Quebec. Source: Blohm et al.

Estranged Space Appropriated

Sana Murrani

Estranged Space Appropriated

In everyday life once the spatial and social conditions are enacted in spacetime they reveal, with varying clarity, worlds that are constantly re-presented, re-structured, re-made, re-appropriated and re-interpreted. To borrow Nelson Goodman's metaphor, worlds melt into other versions of worldmaking, and thus the emerging worlds have relational existence rather than self-existence, i.e. the spatial and temporal position of the created world is nothing but a node in the field of networks of spatial and temporal relations. Simultaneously, the "re" in the re-presentation, re-structuring, re-making, re-appropriating and re-interpreting refers back to the social characterised in the multiple selves and connotations of the body that we encounter throughout our everyday physical, digital, hybrid and augmented participatory experiences. Hence my proposition for this chapter is ontogenic as much as it is ontological. The chapter unthreads the characteristics of the overlaid conditions between the spatial and the social in participatory architecture praxis via a critical discussion into the effects of active perception, network society and participation on the construction and re-constitution of a spatial-technological installation: Overlaid Realities. The theoretical context is based on Goodman's ideology of irrealism and Leibniz's relational theory, and is realised through an interrogation of the ideas implemented in Overlaid Realities installation. It is through this interrogation that the chapter develops into a triadic enquiry of the overlaid ontological (represented by notions of active perception and cognition and their effects on alternative experiences of the world), ontogenic (represented by the relationship between body/self, spacetime, and social flow), and in return, the behavioural conditions of spatial-technological worlds. This work reveals a new theoretical analysis to the way in which we perceive and conceive of spatial-social and technological installations.

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The main proposition for this chapter puts forward an argument that is ontological as much as it is ontogenic. For this reason a combined methodological approach has been adopted in order to follow the complexity of both the being and the becoming of spatial-technological worlds. The assembled methodological approach addresses second order cybernetics in relation to the observer as an active participant within a system and phenomenology relating to perception and the interpretations involved in the making/remaking process of experiencing the world around us. From an outside perspective, one might notice an overall tension and, to some extent, a contradiction in the methodology used here. Perhaps what emerges can be described as a third way philosophy, a dualism that combines the main principles of second-order cybernetics and the fundamentals of post-phenomenology as a methodological approach.[1] The way we behave in a vastly connected and networked society is driven (affecting as well as being affected) by the way we design and experience our spatial and temporal worlds. Therefore, it is necessary to unpack this cause and effect process by applying theories of irrealism[2] and radical relationism.[3] Theories of relationism are dependent on the relational theory of Gottfried Leibniz in which the complex networks of relations between the making/remaking of our spatial temporal worlds in their essence are in fact dependent on our social interaction, interpretations and experiences. The term Irrealism needs some clarification. I will follow Nelson Goodman's theory of irrealism given the nature of the heterogeneous versions of worlds that we are dealing with. Goodman explains what he means by irrealism in his writings:

[1] Murrani, S. 'Third Way Architecture: Between Cybernetics and Phenomenology', *Technoetic Arts: A Journal of Speculative Research* 8(2011), 267-81.

[2] Goodman, N. *The Structure of Appearance*. ed. by 3rd (Boston: Reidel, 1977).

[3] Northrop, F.S. 'Leibniz's Theory of Space', *Journal of the History of Ideas*, 7 (1946), 422-46.

> Irrealism does not hold that everything or even anything is irreal, but sees the world melting into versions making worlds, finds ontology evanescent, and inquires into what makes a version right and a world well-built.[4]

[4] Goodman, *The Structure of Appearance*, p29.

Irrealism differs from anti-realism, accepting possibilities of the existence of knowledge acquired beyond the physical senses, and simultaneously renouncing objective reality.[5] In other words, irrealism is more closely akin to cognition than it is to perception, however, it certainly accepts the notion of worldmaking through the making of, what Goodman calls, "*versions*" of worlds[6], i.e. interpretations. In a way, Goodman's *versions* are mere active interpretations of things (in the hermeneutics sense) via the act of making in spacetime. The physicist John Wheeler explains that we are creating/making our universe through our observations, which are in fact participations; and he relates such behaviour to the nature of our cognitive system.

[5] Bunnin, N. and Yu, J. eds., *The Blackwell Dictionary of Western Philosophy* (Hoboken, New Jersey: Wiley-Blackwell, 2004).

[6] Goodman, N. *Ways of Worldmaking* (Indianapolis: Indiana: Hackett Publishing Company, 1978), p36.

> The universe does not exist 'out there,' independent of us. We are inescapably involved in bringing about that which appears to be happening. We are not only observers. We are participators. In some strange sense, this is a participatory universe.[7]

Therefore, irrealities are versions of active participations via interpretations that are constantly changing, evolving and overlapping through spacetime, and are hence ephemeral. Fundamentally, irrealities are relational and exist on a macro and micro level in relation to any world's ontology and ontogeny. Furthermore, they are highly selective of any world's versions, and therefore, it can be argued that the re-making of versions of worlds improves the quality of social, spatial and temporal relations within that space. This extended proposition is built on Goodman's definition of worldmaking:

> Worldmaking as we know it always starts from worlds already on hand; the making is a remaking.[8]

This action of re-making is in essence the ontological performative theatre known as cybernetics.[9] Goodman's description of worldmaking also denotes W. Brian Arthur's claim that there is an evolutionary process of collective technology whereby the collective evolves through a process of self-creation, where new technologies are constructed from those that already exist.[10] Arthur relates his claim directly to Maturana and Varela's autopoiesis or self-creation which emphasises exactly the same conditions of relational ontology and ontogeny of technology.[11] Second order cybernetics in particular has essentially deepened the cognitive implications and embodiment of "*circular causality*"[12], and in essence depicts the processes of worldmaking and autopoiesis that are mentioned above. Consequently in this chapter, the term *techné* relates to the mechanisms that govern self-creation whilst allowing relational existence within the processes of making and re-making of worlds. This proposition is explained further in the installation section in this chapter.

A third way philosophy, combining elements of second-order cybernetics and phenomenology, emphasises a clear move away from a mere comparison of the dualisms of subject/object, body/mind, self/world and towards an approach that considers the overlaid ontological[13], ontogenic, and in return, behavioural conditions of spatial-technological worlds.

[7] Brian, D. *The Voice of Genius: Conversations with Nobel Scientists and Other Luminaries* (New York: Perseus Publishing, 1995), p127.

[8] Goodman, N. *Ways of Worldmaking* (Indianapolis: Indiana: Hackett Publishing Company, 1978), p6.

[9] Pickering, A. *The Cybernetic Brain: Sketches of Another Future* (Chicago: The University of Chicago Press, 2010), p381.

[10] Arthur, W.B. *The Nature of Technology: What It Is and How It Evolves* (London: Penguin Books, 2009), p167.

[11] Arthur, *The Nature of Technology,* p170.

[12] von Foerster, H. ed., *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems*. 1 vols. Vol. 98, *Macy Foundation: Transactions of the Tenth Conference* (New York: Josiah Macy, Jr. Foundation, 1955).

[13] Ontological conditions are represented by notions of active perception and cognition and their effects on alternative experiences of the world. While ontogenic conditions are represented by the relationship between body/self, spacetime, and social flow.

Contextual Territory

Juhani Pallasmaa highlights the importance of the haptic senses, especially touch and vision, in relation to the architectural experience:

> Touch is the unconsciousness of vision, and this hidden tactile experience determines the sensuous qualities of the perceived object.[14]

[14] Pallasmaa, J. *The Thinking Hand* (London: John Wiley & Sons, 2009), p101-2.

This approach to the relevance of hapticity to the experience of spaces, as much as it is supported by widely known figures in philosophy and through theories of architecture, it is still limited in its relevance to an understanding of the architectural experience with reference to a cognitive conceptual interpretation of meaning through ephemeral representations. In essence, architecture is experienced through the collective users' experiences and interpretations of its different environments. These users vary from the passive to the active and creative, and their changing consciousness is transient due to their differing backgrounds, experiences and memories, as well as their history.[15]

[15] Hill, J. *Actions of Architecture: Architects and Creative Users* (Oxford: Routledge, 2003).

The architect is considered here to be the designer of the seeds and rules of interaction of the game of worldmaking, which are portrayed in spaces and in different worlds through their varied expressions and media of representation. Sir Ernst Hans Gombrich wrote extensively on the subject of art criticism and the interpretation of expression. Gombrich explains the importance of habitual interpretations to the process of perception and describes how interpretations are in fact composed of different stimuli sectioned and grouped in a particular way. By attempting alternative interpretations, i.e., sectioning and grouping stimuli in a different manner, an alternative reading is imposed on reality. Gombrich suggests that *"the adventurous artists"* who use alternative interpretations of stimuli have a greater chance of *"exploring the dazzling ambiguity of vision"*[16] and by this, making their work more open for further interpretations. What is significant here, are the overlaid possibilities of the convergence of different structural constructs to a piece of work where the designer/artist and the viewer/participant have a relationship in determining the emerging situations and events. It is vital for such structural constructs to exist within a field of relations that implies organizing rules designed by the artist to assist the participant through a framework for their emerging interventions.

[16] Gombrich, E.H. *Art and Illusion, 4th Edition* (London: Phaidon Press, 1972), p307.

In essence, this is the main characteristic of the notion of the *"open work"* described by Umberto Eco. Eco speaks of the incompleteness in works of art, or what he termed *"the open works"* and the *"works in movement"*. Eco speaks of *"works"* that are not mere constructs of random components emerging from chaos in which they previously had no relation to each other and were allowed to assume any form whatsoever.[17] Instead, he promotes the openness and dynamism of a work that is an *"'open' situation, in movement"* that installs new relationships between the contemplations of the participants and the creations of the artist/designer.[18]

[17] Eco, U. *The Open Work* (Cambridge, MA: Harvard University Press, 1989), p20.

[18] Ibid, p23.

> The "openness" and dynamism of an artistic work consist in factors which make it susceptible to a whole range of integrations. They provide it with organic complements which they graft into the structural vitality which the work already possesses, even if it is incomplete.[19]

[19] Ibid, p20.

In spatial architectural terms and following Leibniz's and Henri Lefebvre's propositions, the notions of *"open work"* and the *"works in movement"* become apparatus for the re-production of social spaces that are both dominated and appropriated by their participants, and it is in turn necessary for these spaces to be *"occupied"* and re-appropriated[20] in time. Lefebvre unpacks the underpinning of the social relationship between the senses and the material elements, between the body and the drives of subjective and objective articulation of the social relationship[21] based on Leibniz's relational theory where space is substantiated by the mere coexistence of things and bodies in time.[22] Therefore, before us we have a system with dual processes of ontological and ontogenic characteristics that are constantly influencing each other, one being the construct of the incomplete spacetime and the other being the emergent social space via its interpretations and re-appropriations. This system embeds the very essence of irrealism that is both relational and progressional at any instant in time. Towards the end of this chapter this dual process will be developed into a triadic process of ontological, ontogenic and behavioural characteristics.

[20] Lefebvre, L. *The Production of Space* (Oxford: Blackwell Publishing, 1991).

[21] Ibid, p405.

[22] Barbour, J. 'Relational Concepts of Space and Time', *The British Journal for the Philosophy of Science,* 33 (1982) p.251-274.

This oscillation between the relationship of the process of generating social space and its perceptual constructs has been heightened by the introduction of digital and interactive media in architecture through cyberspaces, augmented reality spaces, and other spatial-technological practices. In turn, this has pushed the boundaries and rhythms of analysis and construct of the social space from the body to a meta-level and back, governed by the acts and processes of perception and conception. Relevant examples can be seen in the works of Cedric Price and the Archigram group in their attempt to implement the social and the spatial of the construct of the architectural practice[23] under a less developed technological world than the 2010 Venice Architecture Biennale project, *Hylozoic Ground* by architect Philip Beesley[24] which has implemented the social and the spatial in a technological environment at its best.

[23] Cook, P. *Drawing: The Motive Force of Architecture* (London: John Wiley & Sons, 2008).

[24] Beesley, P. 'Hylozoic Ground'2010) <http://www.hylozoicground.com/index.html> [Accessed July 2010].

The above was a brief overview of the issues surrounding the states of overlaid realities and irrealities present in the processes of worldmaking in architecture, now I will focus on the correlations in-between such states in a collective complex perceptual system.

Overlaid Realities: Spatial-technological Participatory World

Overlaid Realities, the project, was initiated as a response to a call for projects by Plymouth University in collaboration with Plymouth City Museum directed at architects, designers and artists to design interventions that question the relationship between the arts in cultural institutions and their public perception. Building on the ideas of perception, cognition, and appropriation of social space on which this chapter pivots, a multimedia installation was designed. This spatial architectural installation (co-authored and designed with architect Mathew Emmett and technician David Strang), was submitted for *The Cabinet: Changing Perceptions Exhibition* 2011 held in the Peninsula Arts Gallery at Plymouth University.

The installation was inspired by the work of Dan Graham[25] and in particular his piece *Opposing Mirrors and Video Monitors on Time Delay* 1974, in which the viewer becomes both a performer and a spectator at the same time. In a similar way, the installation challenged the ideal and the pristine state of the exhibits we normally come across in museum cabinets and introduced notions of the everyday, the social and the unpredictable.

[25] Graham, D. *Two-Way Mirror Power: Selected Writings by Dan Graham on His Art* (Massachusetts: MIT Press, 1999).

The installation consisted of four museum cabinets; within each there was a computer display and a connected webcam. Pairs of cabinets were arranged facing each other creating a space of 1.5m x 3m. The four computers were networked to each other while each of their webcams was configured to feed its video stream into its computer display. Each of the four computers was displaying the output from its webcam, however that display was delayed for three of the webcams while one streamed in real time. Video signal paths and delays were chosen to create video feedback loops across screens, showing Droste effects. One of each pair of the displays also fed its output into the opposite display of the adjacent pair, which was then blended with the webcam output on that computer, thus creating an infinite array of feedback loops and Droste effects (Figure 1). This meant that a person wandering within the created space would be projected several times as they were captured by the cameras and would appear on all the computers repeatedly and in motion even after they had left the scene. A simple software tool using Max/MSP/Jitter was used to program the interaction between the cameras and displays. The cameras had a wide range which exceeded the actual space of the installation and this meant that even people who were not within the boundaries of that space still appeared as participants.

Overlaid Realities acts as a spatio-temporal participatory and social architectural installation. The project merges the sensory experience of the museum with the environment of the observers, hosting participatory relationships, whilst converging interdependent experiences. The piece exposes elements of participatory and interactive technologies of projected space that put the observer/participant, their body and consciousness at the heart of the subject exhibited through time-based delays and Droste effects. It overlays dualisms of: subjective/objective, real/virtual, and real-time/history archive, in one spatial installation. It integrates principles and processes from the fields of cybernetics, perception, and cognition that are evident in the design, making and experience of the piece. Feedback loop processes are at the heart of its making. Through a state of technological flow and by acknowledging the fact that technology has become an integral and prosthetic part of our lives, the social space created becomes a worldmaking mechanism of multiple overlaid realities. The installation blurs the defined boundaries between museum exhibit and visitor by locating the observer within the system being observed and creating an ephemeral architectural experience.

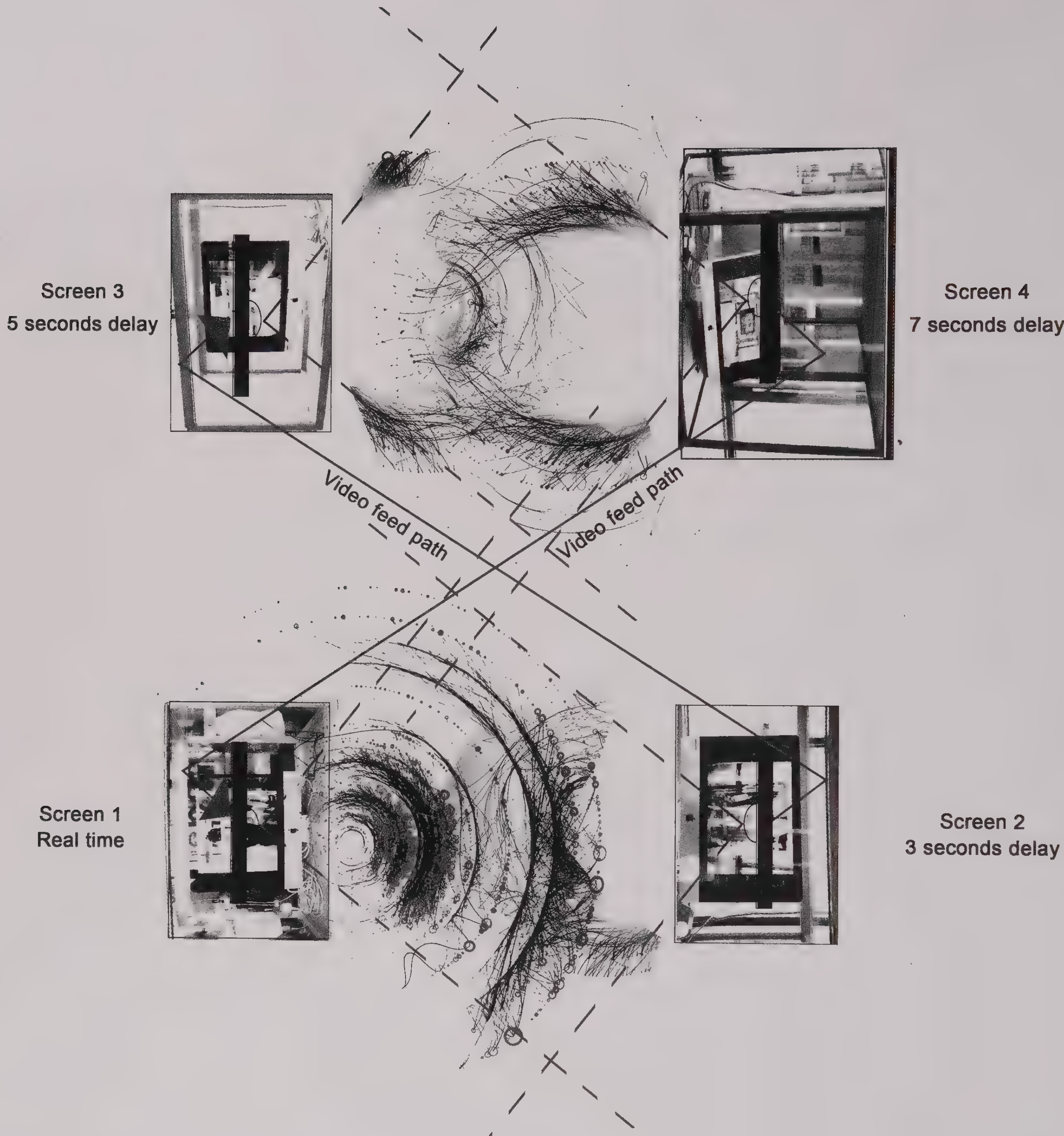

Figure 1: Spatial layout showing video feed connections between the four museum cabinets in the *Overlaid Realities* installation.

In time, as the observers become active participants within the installation, their experiences shift from the merely perceptual to cognitively constructed irrealities. Within the territories of the installation, the participants' interpretations of their worldmaking are in fact processes of grouping of different stimuli from what is being observed, projected/represented, and appropriated in spacetime. Evident firstly in the single and thereafter the collective experiences of the observers is the process of self-creation of their world around them that becomes overlaid on others' via the Droste effect thus producing an irrealism with strong relational existence. Earlier in this chapter, I discussed the meaning of *techné* within the context of this work. *Techné* relates to the mechanisms that govern self-creation while allowing relational existence in the processes of making and re-making of worlds to emerge. The mechanism of grouping the interpretations of different heterogeneous stimuli (self-creation) within the installation, which are constantly changing their position and meaning (relational existence) become the driving force for the generation of different versions of the world inside the world of the installation.

Active Perception: Indirect

In order to delve into the territory of perception and its influence on architectural spatial worldmaking, an account of the theories of perception is required to untangle the perceptual system. More importantly, this section highlights the development and the vital acknowledgment of the move from notions of direct to indirect perception and its impact on the development of the installation presented in this chapter.

A common definition of *perception* in psychology which is useful for our discussion is:

> The neuropsychological processes, including memory, by which an organism becomes aware of and interprets external stimuli.[26]

[26] Soanes, C. and Stevenson, A. 'Concise Oxford English Dictionary, 11th Edition', (Oxford: Oxford University Press, 2009), p1063.

With the focus shifting from discussing haptic senses on their own, to the integration of both haptic and neuropsychological processes, perception emerges as a far more complex process than a mere observation related to a particular phenomenon. In agreement with the above definition, Edward Winters explains that perception does not depend only on the haptic senses but also on the conceptual construction of their meaning as interpreted by the cognitive process:

> That is to say, there is something it is like to perceive something – perception essentially involves a phenomenology – and that in representing the world, perception is conceptually structured; and is thus constitutive of the propositional attitudes that we take up toward the world represented.[27]

[27] Winters, E. ***Aesthetics and Architecture*** (London: Continuum International Publishing Group Ltd, 2007), p115.

Hence, in essence, perception and cognition constitute a twofold process that occupies spacetime. The process of perception then requires a subject-matter (body and space) in an environment, and an observer with his/her own consciousness or conceptual knowledge. All of this does not only depend on the haptic senses in a given environment, but rather, on the extension of the connections and patterns of interpretations between our pre-experiences, our memories, history, transient consciousness, and our active creative self. Many architects and theorists such as Pallasmaa and Holl, and before them, Arnheim and Norberg-Schulz, were and are still locked in the *'direct'* interpretation of perception, the Gibsonian perception, which asserts that senses and their stimuli (i.e. body and object) are the only way to interpret perception. However, later on in this chapter and through the discussion of the installation, it is established that the act of perceiving and conceiving an architectural world is in fact an active rather than a passive process.

Richard L. Gregory believed that perception, especially visual, required intelligent problem-solving based on knowledge which is an active as opposed to a passive process. Furthermore, Gregory puts forward a description of perception, which relates directly to our neurosystem:

> Perceptions are hypotheses, predicting unsensed characteristics of objects, and predicting in time, to compensate neural signalling delay, so 'reaction time' is generally avoided, as the present is predicted from delayed signals.[28]

[28] Gregory, R. 'Knowledge in Perception and Illusion', *Phil. Trans. R. Soc. Lond. B*, 352 (1997), 1121–28.

Gregory established that perceptual and conceptual knowledge are both vital to the overall cognitive experience and at the same time are largely separate as each process occurs in time on a different schedule to the other. Perception works faster, in a fraction of a second, to aid survival; on the other hand conception might take minutes, or sometimes years.[29]

[29] Ibid, p1121.

Theorists such as Max Wertheimer and Kurt Koffka intended to discover the principles that govern how the configurations of whole patterns determine what we perceive, and to provide a theory of brain organization.[30] Early principles in the field of Gestalt psychology aimed to explain perceptual experiences in relation to figures in space through the laws of proximity, connectivity and relativity to its components in its space or environment. However later on, it was established that for each unit or entity in space, there might be a behavioural environment and/or a geographical environment.[31]

[30] Hochberg, J. 'Visual Perception in Architecture', in *Architecture and Visual Perception*, ed. by A.G. Read and P. Doo (Cambridge, MA: The MIT Press, 1983), p38.

[31] Koffka, K. 'From Principles of Gestalt Psychology', in *Perception*, ed. by R Schwartz (London: Wiley-Blackwell, 2004), pp. 50-64.

The idea of the behavioural environment or the behavioural field was first introduced by Kurt Koffka in 1935. Koffka established that some entities exist in the geographical environment but would not necessarily have behavioural fields of existence, and vice versa. The behavioural field is the reflection of the actions, sensations, and meaning of an entity on the observer, while the geographical environment is the actual positioning of the unit in space in a certain time. Koffka explains the independence of the two environments through examples. In the first, he states that by looking at a fragmented figure, our behavioural field will establish that it is a unit, for example a cross, but in reality and in the geographical environment, there is no cross and instead there are eleven dots arranged in a certain geometrical way and there is no connection between them that makes them a unit. On the other hand, Koffka establishes that the existence of real unity is neither a necessity nor an important cause of behavioural unity, as is illustrated in his second example. Here he states that, if a gun is covered with paint in three different parts to blend with the background that it is placed on (in this case the background is made out of a tree, leaves and ground), then the gun will no longer appear to the observer as a unit but rather as a multiplicity of much less important objects.[32]

[32] Ibid, p53.

These two examples explain the move from perception into cognition; this happened at the same time as Gestalt psychologists began to believe that a new theory of brain organization might emerge. In reality Gestalt theorists managed to explain the figure/ground phenomenon as well as some of the laws of organization but they struggled to establish reasons for illusion and other major problems of perception. This was the beginning of the *'direct'* theories of perception, which followed in the footsteps of the classical theory that states that our visual system responds to wavelengths and the intensity of light falling on the eye rather than the actual properties of the objects being observed such as, size, colour, form, etc. In addition to this, perception psychologists established that this response is then added to our memories and past experiences to generate more complex perceptions of objects and spaces, which in turn, emphasises the notion of our perception of the world to being *'direct'*.[33]

[33] Hochberg, 'Visual Perception in Architecture', p40.

Despite their disagreements as to the way in which information taken from the environment is perceived and interpreted, perception psychologists and theorists seem to support the existence of the dualism of the factual environment and the conceptual, or a physical image/environment as opposed to a mental or conceptual one. The notion of a physical environment is closely related to Koffka's ideas of the geographical environment and the haptic and mental environment is a reflection of Gibson's *'direct'* notions and beliefs, while the conceptual relates to the interpretations of Helmholtz's *'indirect'* theory.[34] In effect the processes of perception, conception and cognition are complex and multiple rather than dual or twofold, therefore, a multiple process, temporally and spatially connected and collectively ephemeral could be established between the physical and the sensory as well as the conceptual in order to explain cognitive perception.

[34] von Helmholtz, H. 'Concerning the Perceptions in General (1866)', in *Treatise on Physiological Optics, 3rd Edition* (New York: Dover, 1962).

> Percept and concept turn as one, spinning the fabric of experience, looking always ahead and always back, 'there is no vision without thought.'*[35]*

[35] Merleau-Ponty, M. *The Primacy of Perception*. ed. by J Edie (Ohio: Northwestern University Press, 1964), p175.

This evidence confirms the collectivity, connectivity and circularity of the perceptual system, which brings the field of perception even closer to the notions and principles of cybernetics.[36] Arnheim states that our perceptual experience is far from trivial, regardless of the object or environment being observed due to the openness of the system.[37] These active interactions between the three main elements of a perceptual field; the object/space, the environment around it (its context), and the observer's consciousness, are confirmations that the perceptual experience is an active open system. Despite establishing ontologically that the perceptual field and the visual apparatus in general are active processes, it is not sufficient to explain the dynamics of the perceptual experience as an ephem-

[36] Murrani, 'Third Way Architecture', p271.

[37] Arnheim, R. 'Gestalt Psychology and Artistic Form', in *Aspects of Form*, ed. by LL Whyte (Burlington: Lund Humphries, 1968), p203.

eral system. The observer and the context or their world(s) being percept and concept are both very important variables in this system. According to Jonathan Hill there are three types of user or observer, the passive, the reactive and the creative. All three of Hill's user styles could be observed in the behaviour of those who entered the installation:

> The passive user is predictable and unable to transform use, space and meaning. The reactive user modifies the physical characteristics of a space as needs change but must select from a narrow and predictable range of configurations largely defined by the architect. The creative user either creates a new space or gives an existing one new meanings and uses. Creative use can either be a reaction to habit, result from the knowledge learned through habit, or be based on habit, as a conscious, evolving deviation from established behaviour.[38]

[38] Hill, *Actions of Architecture*, p28.

During the construction of the installation, *Overlaid Realities*, the initial intention was to provoke the norm, to challenge the static condition of the exhibits within a museum cabinet and instead to place the viewer within the cabinet to trigger interpretations and provoke interactions. By focusing on the most direct haptic sense, vision, the streaming of participants' self-projections triggered the creative users to explore their environment while the Droste effects allowed for the conceptual cognitive interpretations of 'their' space to emerge. This was one of the installation's main goals. The exposed technology revealed a network of connections and cables which appeared naked before the participants helping them to solve the puzzle of the 'illusion' projected onto the four screens (Figure 2). The intention of this exposure was to trigger active perception through participation and experimentation. One participant's view was: *"Your installation made me pause and think, thank you"*. However, not all participants were active or creative participants. This was part of the appeal of the installation, allowing the social to appear in its messy, everyday, unaffected behaviour. In this instance, mess was certainly a condition in the life of the installation; this notion is supported in a statement made by Jeremy Till in his quest to define the various conditions that architecture as a praxis field depended on, where he states: *"Mess is the law"*.[39] The spatial and social interactions between the participants meant that their creative and passive input could overlap to produce a better understanding of the world or versions of the world created through the installation, or in other words, irrealities.

[39] Till, J. *Architecture Depends* (Massachusetts: MIT Press, 2009), pxii.

Figure 2: Indirect perception of the *Overlaid Realities* installation.

Multiple networks of body/self(s) and spaces(s): The Social Mess

Roy Ascott opposes the need for the centrality of the existence of the body in the system of perception but rather suggests that networking takes the physicality of the body out of the system by linking the mind to a kind of timeless sea[40] and by doing so, the focus moves onto the transformation of the artwork, or as Ascott calls it *'creative data'*, which appears in a constant process of becoming and perceptual motion. However, the relationship between the body, the creative data and perception is in constant oscillation. Merleau-Ponty in his book the *Phenomenology of Perception* confirms the relationship of the body to a theory of perception:

> [...] we need to reawaken our experience of the world as it appears to us in so far as we are in the world through our body, and in so far as we perceive the world with our body. But by thus remaking contact with the body and with the world, we shall also rediscover ourself, since, perceiving as we do with our body, the body is a natural self and, as it were, the subject of perception.[41]

Therefore, in order to understand the world(s) around us we need to understand the relationship between our body and its space. This is clearly an ontological and an ontogenic relational proposition. An example of such a relationship is evident in the dichotomy between the proportions of Le Corbusier's *Modulor Man* and the *Sensory Homunculus* in relation to body and space illustrated around them. The Modulor Man relates to the space around it through a direct Cartesian relationship, while the *Sensory Homunculus* relates to the space around it proportionally via its senses and perceptions. This dichotomy is one of the most effective demonstrations of the multiple representations of the relationships between body, space and perception. Philosophers for centuries debated this relationship and even though Aristotle believed in a rigid physical relationship between body and space, he ignored the existence of a body other than the physical body. Not until Kant, Husserl, Merleau-Ponty and later on, Foucault, Deleuze and Guattari were the changing human experience and the perception of place and space accounted for.[42]

Gilles Deleuze and Félix Guattari suggest different connotations of the relationship between the body and place with their theory of the *'Body without Organs'*. They describe the *Body without Organs* as the egg

[40] Ascott, R. *Telematic Embrace: Visionary Theories of Art, Technology and Consciousness* (Berkeley, CA: University of California Press, 2003), p187.

[41] Merleau-Ponty, M. *Phenomenology of Perception*. trans. C Smith (London and NY: Routledge, 2002), p239.

[42] Casey, E. *The Fate of Place: A Philosophical History* (Berkeley, CA: University of California Press, 1998), p332.

before the extension and development of the organism, being defined by gradients, thresholds, axes, vectors, dynamic tendencies and energy transformation, where the organs appear and function out of intensities. [43] By intensities Deleuze and Guattari mean fundamental abstraction, where matter equals energy, when both equal zero. In biological terms this means when a hypothetical equilibrium pushes form and space to the edge between order and chaos, and where emergence begins its non-linear loop again. For them, the *Body without Organs* or *BwO* is:

[43] Deleuze, G. and Guattari, P.F. *A Thousand Plateaus* (London: Continuum International Publishing Group Ltd., 2004), p170.

> A BwO is made in such a way that it can be occupied, populated only by intensities. Only intensities pass and circulate. Still, the BwO is not a scene, place, or even a support upon which something comes to pass. It has nothing to do with phantasy, there is nothing to interpret. [...] It is not a space, nor is it in space; it is matter that occupies space to a given degree – to the degree corresponding to the intensities produced.[44]

[44] Ibid, p169.

Similarly to the different ideologies of the body in relation to space, there are multiple ideologies of space itself that become the direct construct of our worlds, for instance, physical space, cyber space, virtual space, interactive space, and even empty space. Deleuze and Guattari speak of the smooth and striated space by which they relate space not only to its ontological characteristics but also to its ontogenic condition being heterogeneous or homogenous.[45] There are parallels that can be drawn between Deleuze and Guattari's *Body without Organs* and the empty space that Georges Perec identifies in Lewis Carroll's nonsense poem *Map of the Ocean* in *Hunting of the Snark*. Perec identifies and lists different species of space which he then summarises in one definition, explaining:

[45] Ibid, pp474-500.

> In short, spaces have multiplied, been broken up and have diversified. There are spaces today of every kind and every size, for every use and every function. To live is to pass from one space to another, while doing your very best not to bump yourself.[46]

[46] Perec, G. *Species of Spaces and Other Pieces* (London: Penguin, 2008), p6.

The construct of space is dependent on the occupation and appropriation of that particular space which is in turn dependent on the participants within that space and their consciousness, perception, cognition and interpretations. This network and connections of dependencies are in fact the core of what constitutes the messy nature of this work which extends to other dependencies, be they social, economic, political, etc. It is not the core purpose of this chapter to explore different kinds of space or body but it is necessary to build a clear hypothesis of the dependence established between body and space in relation to their representation as well as the overall collective cognition experience. The entanglement in the relationship between body and space in this section is a proof of the complexity of the subject of perception and cognition as well as their construct. This complexity confirms that our problem is ontogenic as much as it is ontological. There are several variables involved in the perceptual system, which act individually and collectively at the same time within this complex ontogenic system. These main elements are, the sensations (the haptic senses), the perceptual field (the environment whether it is a geographical or behavioural one), the body/observer with their own consciousness and conceptual constructive knowledge and the medium in which the world(s) take(s) place. These elements follow principles and processes within the perceptual field, such as connectivity, collectivity and circularity between each other through certain media. The observer on the other hand carries a different status being passive and/or active, present or absent, depending on their preconceptions, conceptions and beliefs as well as different appropriations of their worlds.

The space that was created and the space that emerged (occupied and re-appropriated) out of the *Overlaid Realities* installation were distinct at all times. The emergent space certainly depended for its existence on the participants' interactions (Figure 3). On the one hand, the lack of such participations meant that the projections were still and empty and rendered the space dead. On the other hand, lively interactions added the vital element of social mess (to adopt Till's term) that comes with notions of the everyday.[47] The openness of the rules of the game implemented within the installation meant that what emerged was a result of the occupation of space for the sake of re-appropriations and interpretations and not for the celebration of the design of the space itself. The architects of the installation meant to take a step back in the process to allow social behaviours to materialise.

The triadic relationship between body, space and the social resonates with Merleau-Ponty's theory of the corporeal that holds the body and the world to be the fundamental structures of being.[48]

[47] de Certeau, M. *The Practice of Everyday Life* (Berkeley and Los Angeles, California: University of California Press, 1984).

[48] Merleau-Ponty, M. *La Nature: Cours De Collège De France 1956-1960* (Paris: Seuil, 1994), p343.

Corporeity in Merleau-Ponty's philosophy interconnects the body directly with consciousness and thus provides the framework for social relations to exist between body and world, body and self, and body and space via active perception experiences.

Behavioural Worlds: State of Flow

Manuel Castells establishes that spaces are expressions of society and culture, and emphasises that they are expressions rather than reflections of society. Castells limits the definition of space to the material world on the assumption that:

> "[…] space is a material product, in relationship to other material products – including people – who engage in 'historically' determined social relationships that provide space with a form, a function, and a social meaning."[49]

[49] Castells, M. 'Chapter 6: The Space of Flow', in *The Information Age: Economy, Society and Culture - the Rise of the Network Society* (Oxford: Blackwell Publishers Ltd., 2000), p441.

While Castells refers to space as a material product in its relationship to other material products, Lefebvre agrees with Castells on considering space a product but he disagrees fundamentally on what type of product it is. Lefebvre certainly argues, "*(Social) space is a (social) product*".[50] It is important to establish that space is not an abstract matter but rather is based on social assemblages and connections.[51] Moreover, it appears from the natural development of this argument that space is social. But can we consider the social to be a type of material? According to sociologist Bruno Latour considering the social as a mere type of material is in essence one of the common fundamental errors one can make in its definition. Instead Latour relates the social to two different phenomena, stating that on one hand it relates to materialistic substance, and on the other hand it is a movement between non-social elements and their connections, associations and collective.[52] Therefore, the social in its definition oscillates between stasis and constant movement, between associations, connections and relations, building up assemblages, appropriations and interpretations and is hence always in a state of flow. The state of flow concurrently occurs between space and the social. Strictly speaking, flow is constantly restructured between a network of spaces and social collectives in time. Our world around us is

[50] Lefebvre, *The Production of Space*, p26.

[51] Till, *Architecture Depends*, p126.

[52] Latour, B. *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005), p159.

Figure 3: The social participants' spatial timeline in the *Overlaid Realities* installation.

Figure 4: Diagram showing Droste effects over time: The social mess in the *Overlaid Realities* installation.

governed by a state of flow, and this in return is conditioned by our social relations and ultimately by our behaviour. The vitality of the existence of the state of flow in relation to our spatial, temporal and social relations is associated directly with our ability to re-assemble, re-organise, re-make, and re-appropriate such relations, which is what Leibniz, Goodman, Gombrich, Lefebvre, and Latour collectively address.

During the opening night of the Changing Perceptions exhibition, the space of the installation *Overlaid Realities* began to accumulate a number of meanings over time. Initially it became a strange space with participants rejecting the "Big Brother" like observations captured and streamed on the four screens. Later that estranged space became more familiar and the participants tentatively began to explore its material and process at the same time. However, it was not until social nodes began to emerge that the piece fulfilled its potential, when participants began to interact with each other to trigger different Droste effects over time (Figure 4). The installation itself was technically very simple and operated according to fixed rules, however, the emergent behaviours of its space(s) and its participants were highly networked and complex in their relations. According to these relations the installation exhibited multiple states of flow, flow of materials (physical and electronic); flow of movement (people and spaces); and social interactions on a haptic and a collective level. The space of flows began to blur the relationship between architecture and the social.

The installation was built to expose the characteristics of a behavioural world on a small scale. It exhibited a facilitating role, which allowed technology to heighten the definition of simple rules to be played by heterogeneous actors, be it participants, their consciousness, interpretations, fragments of space, or time, etc. The emergent spatial-technological and social praxis of the installation was versatile and could be applied in other contexts and on different scales. The praxis advocates a bottom-up relationship for the designer/architect to their designs and allows the users, participants and inhabitants to occupy, re-appropriate, re-assemble, and re-make their environments. Through a nonlinear system of relations, irrealisms have pushed the re-making of versions of worlds to a state of ephemeral emergence, thus creating new social nodes and spatial flow. The act of re-making, re-appropriation, and re-interpretation improved the qualities of the social in space via a triadic construct of ontologic, ontogenic and behavioural flows. Based on ideologies of irrealism, relationism and third way philosophy, the installation heralds principles of cognition and indirect perception for a state of flow in a behavioural world between spacetime and the social; and hence remains ephemeral and relative.

The intertwined relationship between spacetime and the social is dynamic in its making, or more accurately, re-making, and also in its behaviour. The ontology of spacetime becomes evanescent through the behaviour of the social interactions of the participants, their embodiments and perceptions. Such embodiments expose the nature of the heterogeneous social spaces that influence flow in the wider social context, the network, and the ecology of life; the mess of the everyday.

Sentient Canopy: Prototype for resilient, curious architecture

Philip Beesley

A second nature with which to remake the crust of the earth, one that neither opposes nor dominates nature but rather extends it. – Detlef Mertins[1]

[1] *Modernity Unbound: Other Histories of Architectural Modernity*, (London: Architectural Association Publications, 2010).

This reflection provides a description of an architectural canopy, framed by a cultural discussion contributing to the reform of a long humanist architectural tradition of stripped stages and closed boundaries. The canopy prototype consists of four interdependent layers: a physical structure that forms the space as a forest of deeply interwoven material; an electronic system that includes sensors, actuators, and microcontrollers; firmware that provides low-level functionality at the microcontroller stage; and software that is executed on a remote computer and provides higher-level intelligence. Together, these layers form a meshwork characterized by resilience and hybrid coupling.

Design paradigms for shelter built upon the solid, eternal ground of Vitruvian foundation might render the task for architecture simple. Springing from foundations secured by the cardinal powers of the earth, one of the primary tasks of a building envelope might be rendering the outer world vividly, consuming the environment and serving my outward-seeking gaze. A functional definition of this architecture could describe building envelopes as filters that enclose human bodies and draw the environment inward and outward, sheltering the interior and amplifying the experience of the surrounding world. Yet the great extinction now sweeping our environment has swept away such transcendent qualities. The ground is yawning, viscous, inducing queasy vertigo. My legs unconsciously tense themselves, reptile brain–inflected posture tensed by the elastic meniscus underfoot. The shift of my own posture inverts any confident gaze, and the enclosing function of architecture shifts from consuming the surroundings.

Visions of an orchestrated Earth have a long and confident history, especially in the anthropocentric cosmologies announced by Renaissance and Enlightenment imagery. In canonical Annunciation paintings, such as Sandro Botticelli's *Annunciation 2* (1489–90)[2], graceful figures of Gabriel and Mary appear standing upon a gridded stage, with a carefully ordered garden stretching behind into the distance. Gabriel and Mary are clearly the masters in this scene, with nature polarized as the servant. Similarly, the nuanced exchanges of figures standing calmly within Piero della

[2] http://www.sandrobotticelli.net/The-Annunciation-2.html [last accessed May 31st, 2016]

Figure 1. *Sentient Chamber*, interactive geotextile mesh environment, includes embedded machine intelligence and 'living' chemical exchanges. Sentient Chamber, National Academy of Sciences, Washington D.C. USA (2015).

Francesca's *Flagellation of Christ 3* (1455–1460)[3] are framed by a gridded stage. In that scene, historical figures are cast as contemporary Florentine citizens, earnestly conversing while standing in an ordered plaza marked by flooring that recedes in meticulously drafted perspective. The parallax of this scene is constructed to coincide with the viewer's own viewpoint, implying common citizenship. These staged public spaces speak of human domain as a pinnacle of achievement. It is tempting to draw a parallel between this kind of geography and twentieth-century control systems. Such territory seems to coincide with Modern visions exemplified by the Twentieth-Century American engineer Buckminster Fuller's radiant 'geoscope,'[4] a floating spherical instrument panel connecting to vast networked global systems, focusing the entire world into a coherent, unified vehicle for organized operation.

Yet when preceding generations of theorists considered the nature of these ordering systems, their arguments were divided. In their widely published 1830 debate, Etienne Geoffroy Saint-Hilaire and Georges Cuvier, founding biologists of the Museum of Natural History in Paris, examined the basis of nature.[5] Against Cuvier's rear-guard defence of a 'Great Design' determining individual species' anatomy, Saint-Hilaire argued that anatomy determined how a species behaved, opening the door to speculations about nature divorced from theology.[6] Saint-Hilaire implied that there was no particular 'transcendent' destiny involved in individual functions, only concrete and 'immanent' functions that would create particular opportunities for behaviour.[7] Saint-Hilaire's argument resonates with the words of Lucretius, two millennia preceding stated: "Nothing in the body is made in order that we may use it. What happens to exist is the cause of its use."[8]

Similarly polarized debates between transcendent and immanent orders exist in areas beyond Darwin's preoccupations of natural selection and genetic mutation. Building a new kind of stewardship from immersion in complex systems of nature, a reverently transcendent vision of creation was evoked in Haeckel's illustrated folio *Art Forms in Nature*[9], which illustrated Darwin's vision of the practical evolution of species before treading into virulently racial judgements. Both for Haeckel and for the generation that followed, manipulation became fraught. D'Arcy Wentworth Thompson's

[3] http://www.wikiart.org/en/piero-della-francesca/the-flagellation-of-christ-1450-1 [last accessed May 31st, 2016]

[4] https://en.wikipedia.org/wiki/Geoscope [last accessed May 31st, 2016]

[5] Alexander McBirney and Stanton Cook, "Debate between Cuvier and Geoffroy Saint-Hilaire," in *The Philosophy of Zoology Before Darwin*, (New York: Springer, 2009), 99-108.

[6] Ibid.

[7] Ibid.

[8] Titus Lucretius Carus, *Lucretius the Way Things Are: The De Rerum Natura*, trans. Rolfe Humphries (Bloomington: Indiana University Press, 1969), 833.

[9] Ernst Haeckel, *Art Forms in Nature* (Leipzig: Bibliographisches Institut, 1904).

1917 opus *On Growth and Form*[10] offered practical methods for manipulating dynamic forces. While Thompson's benign influence on design has been repeatedly cited, the political application of his methods to improving the human species through eugenics is poignantly evident.[11] Ambivalence takes an explicit form in nuanced readings offered by Wilhelm Worringer in *Abstraction and Empathy: A Contribution to the Psychology of Style*, published in 1908.[12] Worringer wrote: "Whereas the precondition for the urge to empathy is a happy pantheistic relationship of confidence between man and the phenomena of the external world, the urge to abstraction is the outcome of a great inner unrest inspired in man... [corresponding] to a strongly transcendental tinge to all notions. We might describe this state as an immense spiritual dread of space."[13]

[10] D'Arcy Wentworth Thompson, *On Growth and Form* (Cambridge: Cambridge University Press, 1917).

[11] Ibid.

[12] Wilhelm Worringer, *Abstraction and Empathy*, trans. Michael Bullock (Chicago: Ivan R. Dee, Inc., 1997).

[13] Ibid., 15.

The geologist and theologian Teilhard de Chardin developed a compelling historical vision that I believe offers subtle resolution of this contested ground. Working between 1920 and 1955, De Chardin voiced hope for the emerging qualities of integrated world organization, rooted in the voluntary organization of overlapping networks of individuals.[14] Increasing multiplication and overwhelming density of networks created coherence that might in turn result in a 'noosphere' of collective consciousness. Averring homogenous unity, De Chardin said, "in any domain—whether it be the cells of a body, the members of a society or the elements of a spiritual synthesis—union differentiates."[15] Most poignantly, De Chardin hoped that this consciousness would be accompanied by an emerging 'prodigious affinity,' a tangible collective sympathy, acting at global collective scale.[16]

[14] Teilhard de Chardin, *The Phenomenon of Man*, trans. Bernard Wall (London: Collins, 1959).

[15] Ibid., 262.

[16] Ibid., 262.

The series of work illustrated here follows De Chardin's invitation. A general objective of the work is to find a new role for architectural environments, transforming portions of static buildings into dynamic responsive generative surfaces. A corresponding ethical objective is to find sensitive, renewed relationships for human occupants interconnected with their surrounding environment. The work examines how people perceive and interact with their surroundings. The clearly defined barriers between object-subject become blurred and the introduction of mutual interaction suggests a paradigmatic shift toward subject-subject relationships seeking an efflorescence of involvement and exchange. Borrowing from post-humanist discourse, near-living architecture removes human agency from a primary, Vitruvian centre and places it into an active environment where near-consciousness and liminal states of diffuse agency are possible.

Can soil be constructed? The project offers design details that feature extremely lightweight, sensitively tuned actuators capable of vibrations and trembling, implying an emotional range that could support vulnerability and fragility in an expanded spectrum alongside robust, highly playful behaviours. The architectural craft that is in development to support this work involves designing with materials conceived as filters that can expand human influence while at the same time expanding the influence of the surrounding environment upon human occupants, emphasizing oscillating functions of catching, harvesting, pulling and pushing. Building on these direct, emotional expressions, works by the Living Architecture Systems Group (LASG) (a partnership of architects, engineers, scientists, and artists from Canada, the U.S., and Europe) are characterized by models of open-ended exploration, tending to emphasize the role of each occupant in orienting themselves and interacting with the complex environments. In these environments, occupants and build up a deeply layered, deeply fissured set of relationships in which there are multiple sensitive boundaries. The pursuit of these spaces could be considered as a synthetic new kind of expanded 'soil'. Ultimately, the work explores the possibilities of future built environments and how we can radically redefine how we build and live in our cities.

These environments are composed of thousands of digitally fabricated metal, acrylic, mylar, and glass elements. The massive replication of components is organized within tension-based resilient scaffolds, creating diffusive boundaries between occupants and their surrounding. The environments are based on designs that seek to maximize interchange with the atmosphere and occupants. Designs are based on deeply reticulated skins, contrasting to the minimum surface exposures of reductive crystal forms that have tended to organize contemporary building designs. Amplifying physical motions related to interaction with viewers and occupants, the details of many components in these sculpture parts are designed to tremble and resonate, responding to slight shifts in the surrounding environment.

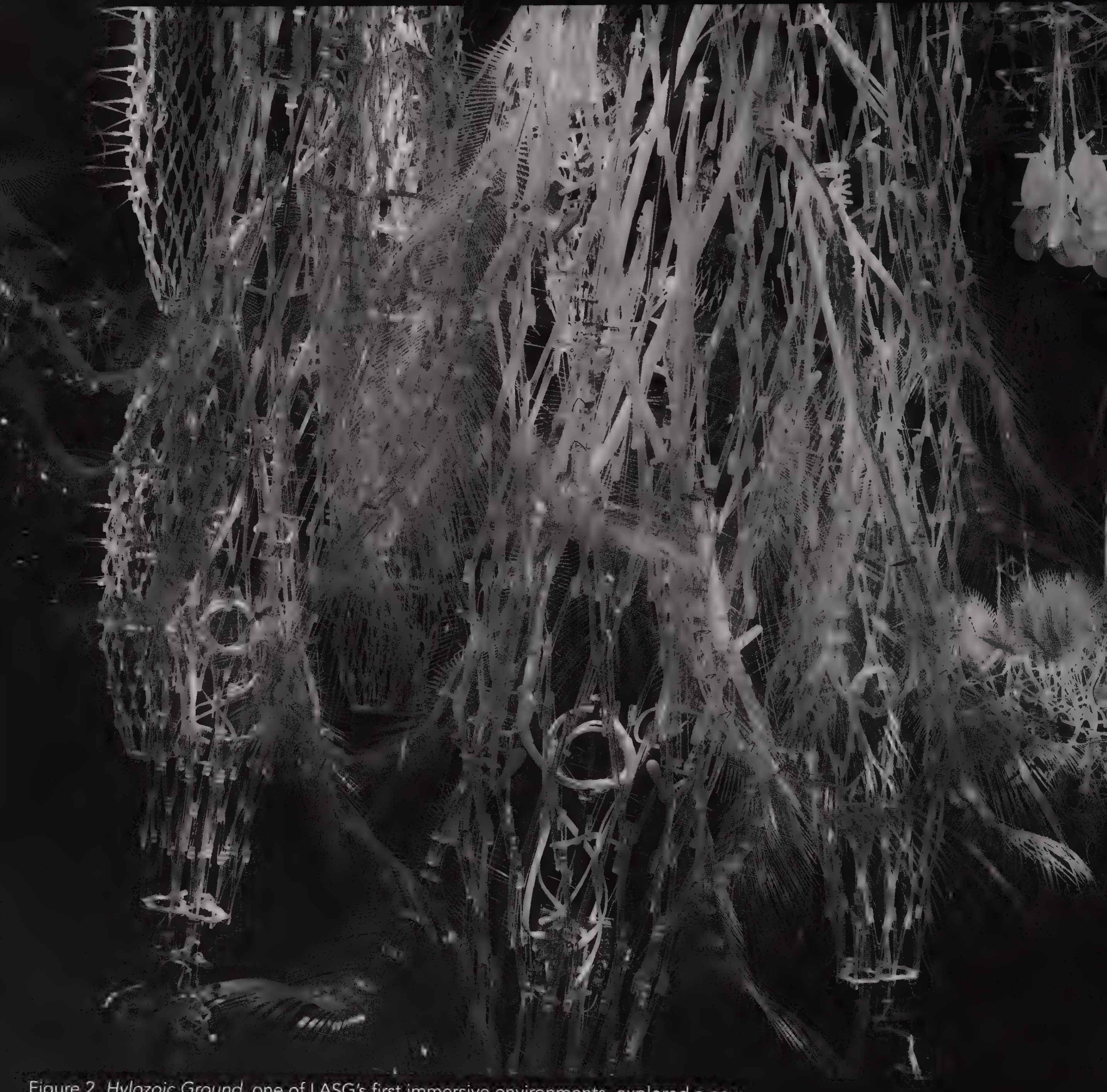

Figure 2. *Hylozoic Ground*, one of LASG's first immersive environments, explored a new generation of responsive spaces, conceived as a synthetic soil that might take root within architecture. Hylozoic Ground, Venice Biennale, Italy (2010).

Philip Beesley: Sentient Canopy: Prototype for resilient, curious architecture

[17] *Sentient Chamber*, National Academy of Sciences, Washington D.C., 2015-16.

[18] Ibid.

Sentient Chamber[17] (Figure 1) is a free-standing pavilion that offers a compact prototype whose experimental constructions imply models of future architecture. *Sentient Chamber* was created in collaboration with the LASG, and exhibited at the Cultural Programs of the National Academy of Sciences Building on the Washington Mall during 2015 and 2016.[18] The work combines three new systems of structure, electronics and software controls. This speculative architecture and sculpture installation acts as a test-bed for ongoing research that combines the disciplines of architecture and visual art, computer science and engineering, and synthetic biology. Ensoiled fabrics make an offering, treading contested ground. Oscillating drifts of hyperbolic and quasiperiodic geometry that guide this work lie far from transcendent, overarching order. Like the shimmering tesserae of an ancient Byzantine mosaic caught between worlds, the fabric of the chamber oscillates.

The new structural system is organized by a hybrid triangular flexible space-grid (Figure 4), stiffened by expanded-mesh hexapods that support telescoping posts and spires contacting the floor and ceiling for stability. This structure offers minimal material consumption, achieved through highly efficient advanced manufacturing employing laser machining and thermal forming of expanded meshwork. Tensegrity coupling is featured, employing metal rod cores that stabilize the system surrounded by meshwork hyperbolic shells that provide alternating tensile and compressive support.

Electronic controls employ powerful microcontrollers, expanded by custom circuitry for local communications, power control and sensor feedback. Proprioreception is a particular feature of this new system. Arrayed electronically controlled acoustic and kinetic mechanisms are accompanied by sensors that provide internal feedback to the control system, supporting machine learning. In turn, these nested arrays are supported by a central computer configured with three coupled control softwares, providing a test-bed capable of orchestrating pre-scripted behaviours, relationships between components, and learning functions. Currently under development is a new curiosity-based learning algorithm (Figure 5). The system offers interactions with viewers that include spatially imaged sound, light, vibration, and concentrated movement mechanisms, each supported in overlapping nested arrays housed within the hybrid structure.

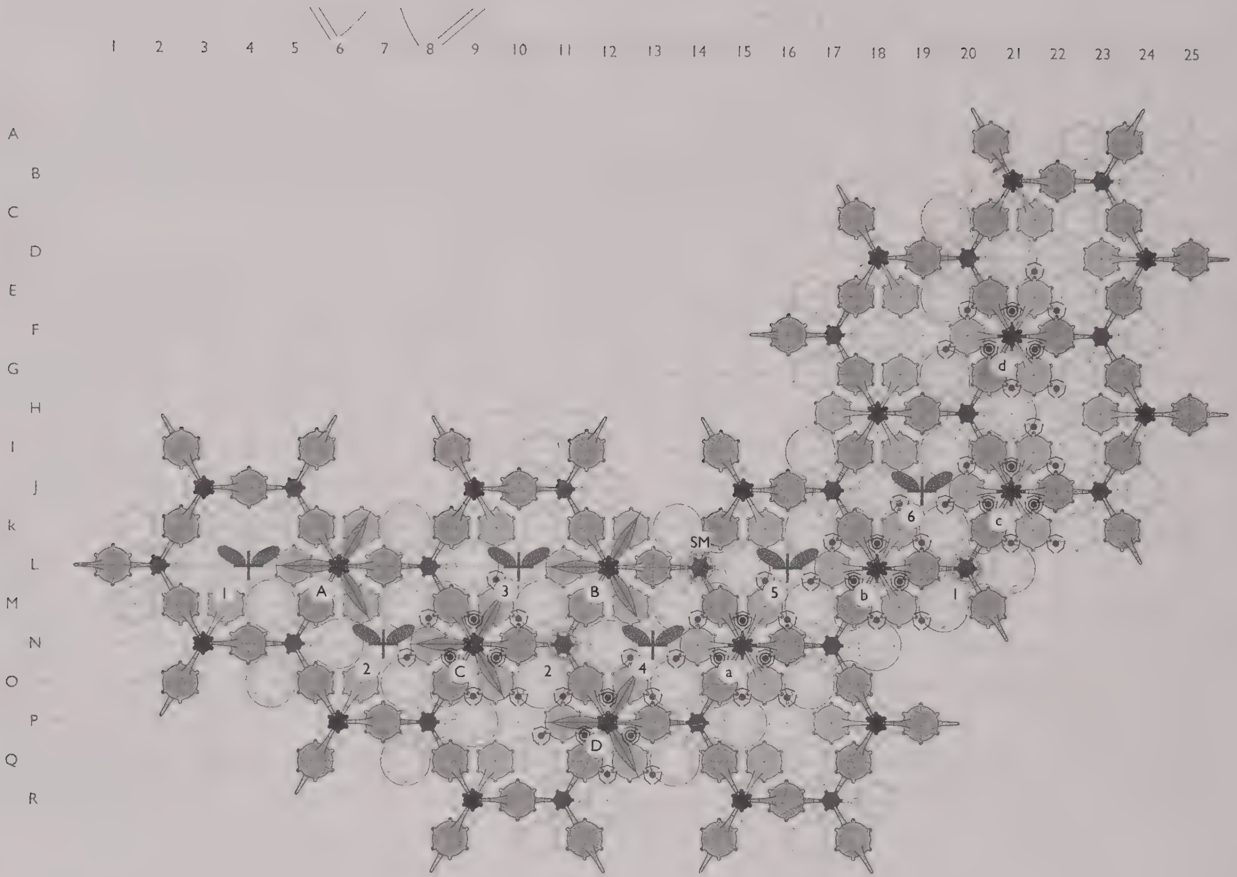

Figure 3. Plan of *Sentient Chamber* showing modular combinations of structural scaffold components integrated with mechanisms and sensor clusters. The structural design follows diffusive crystalline forms.

The electronics form the basis of the interactive system that imbues the canopy with a prototypical sentience. The canopy's primitive intelligence is distributed throughout its structure in a series of connected nodes. These nodes are each centred around microcontrollers that provide the interface to an array of sensors and actuators. An array of sensors and actuators form the canopy's perceptive and reactive body and are configured to allow the canopy to perceive and influence its own physiology as well as its environment. This ability to self-sense is called proprioception and is an essential capacity for an intelligent system that can understand itself within the context of its environment.[19]

[19] Oudeyer, Pierre-Yves, Frdric Kaplan, and Verena V. Hafner. 2007. "Intrinsic Motivation Systems for Autonomous Mental Development." *IEEE Transactions on Evolutionary Computation* 11 (2): 265–86.

Firmware refers to the portion of code that is written for and executed on these microcontrollers. Simple behaviours, such as the generation of sound, fading of lighting, and cycles of motion within the canopy are produced at the firmware level. The firmware also plays the role of translating raw sensor data into signals that can be used by the software as representations of the sensed environment.

Kinetic devices carry new electronics hardware associated with the curiosity-based learning algorithm being developed to control the new responsive structure. Mobile proximity sensors are positioned mechanisms, with feedback controls. The arrayed mechanisms offer continuous, active responses that can work individually and that can also be chained together for large-group dynamics. This system offers a unique, physical kind of machine vision that offers complex responsive kinetic functions. For example, occupants interacting with this system could find arrays of individual fronds following their motions accompanied by outward-rippling motions. Increased complexity approaching peer-like playful kinetic responses could, with further development, result from this novel interactive arrangement.

In previous installations, the interactive behaviours of the sculptures were pre-scripted. Each node responded to occupants and influenced the behaviours of its neighbouring nodes following established patterns. New systems continue to support the design and implementation of pre-scripted behaviours. Because of physical complexity and proximal coupling, non-deterministic patterns can emerge through the interactions between pre-programmed nodes.

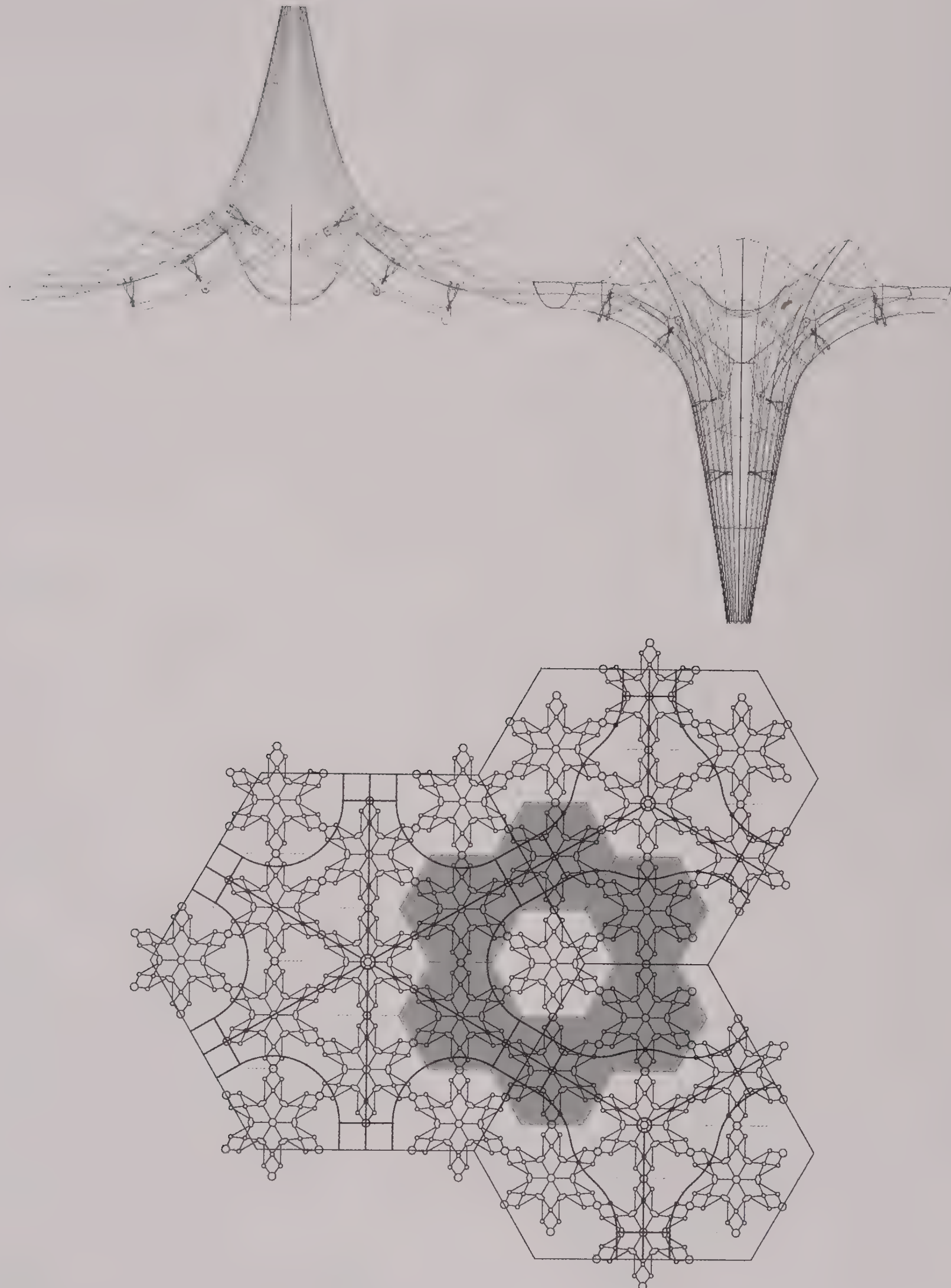

Figure 4. *Sentient Chamber* is supported by a hybrid triangular flexible space-grid structure, that provides flexibility and stability through tensile and compressive support.

A curiosity-based learning algorithm (CBLA) is used as a general control. In the CBLA framework, pre-scripted behaviours are replaced by lists of input and output channels that the system can observe and control. The CBLA engine aims to learn about the relationship between its actions and its sensory observations. Driven by an intrinsic desire to learn, *Sentient Chamber* will try to understand itself, its surrounding environment, and the occupants, through active mobilization and interaction (Figure 6). The control system considers a set of behaviours, and predicts the outcome of each of the behaviours. It then chooses one of the behaviours to execute, observes the outcome and compares its prediction to its observations. The CBLA is configured to select actions that are outside of its past experience and for which its predictions of the outcome are mostly likely to be vary. This configuration ensures that the canopy and its nodes continue to find and explore unfamiliar patterns.[20]

[20] Matthew T. K. Chan, Rob Gorbet, Philip Beesley and Dana Kulić. 2015. "Curiosity-Based Learning Algorithm for Distributed Interactive Sculptural Systems." In *2015 IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS), 3435–41. IEEE.

Each node learns and explores its own subset of the system. The distributed nodes are coupled to each other both physically, by sharing sensors, and virtually, by considering node outputs as inputs to other nodes in the system. This coupling creates the potential for neighbour and group behaviour by connecting the perceptive spaces of each node.

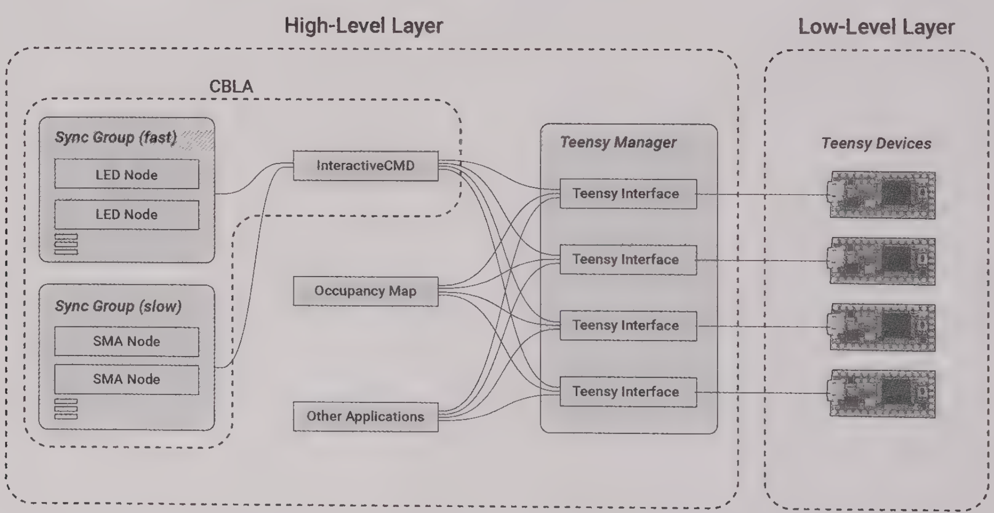

Figure 5. Communication between the high-level and low-level software layers including the curiosity-based learning algorithm.

The CBLA functions by exploiting the system's inherent curiosity to learn about itself, much like an infant might learn by exercising groups of muscles and observing the response. In its simplest form, the algorithm chooses an action from its action repertoire to perform, and measures the response. At the same time, it generates a prediction of what it thinks should happen. If the prediction matches the measured response, it has learned that part of its sensorimotor space and that space becomes less interesting for future actions. If the prediction fails to match the measured response, it remains curious about that part of its "self," as it obviously still has more to learn. It will create a new prediction and try again. This learning architecture allows the system to learn both about itself, and also about interactions with occupants, whose movements and actions create new and "surprising" responses, activating the system's curiosity.

The *Sentient Canopy* implementation described here integrated the new communications protocol and firmware, new electronics, and a proprioreceptive system including sound, light, and motion sensing capable of both internal machine sensing and externally-oriented sensing for human interaction. These innovations help support precise manipulation of this relatively unstable software routine and help support methods for visualization and analysis. A modular, object-oriented framework was developed for firmware that allows for rapid extension and configuration of nodes. An Arduino-compatible node-based electronics system was designed and implemented that exposes dense sensing and actuation capabilities to a flexible array of sub-node (device) level modules allowing for the inclusion of a wide range of low-voltage peripheral devices including shape-memory alloy and DC motor-based mechanisms, amplified sound, and high-power LED lighting. Proprioception was implemented by producing custom electronics serving photoresistors, pitch-sensing microphones, and accelerometers for motion and position, each coupled to sound, light and motion-based actuators and additional infrared sensors designed for sensing of human gestures. This configuration provides the machine system with the ability to calculate and detect actual behaviour, and to compare this to behaviours predicted by the system's knowledge to date, allowing the system to explore and experiment with new behaviours. The configuration supports machinic introspection.

Figure 6. An audience member interacts with *Sentient Chamber*, as it attempts to learn from the individual appropriate actuated responses

With more development, the process described here can provide a means for the predictive simulation and testing of different behaviours. The eventual aim of a digital representation is not only to visualize the physical effects and learning status, but to support an informational space that can act as an interface capable of controlling the physical system. The real-time visualization of phenomenon such as light, sound or the learning process can feed back into the physical installation and modify its learning pattern or trigger actions based on emerging patterns discovered within the digital visualization.

Physical interconnection of light, sound and motion-based sensor and actuator systems can result in hybrid relationships. Within these test-beds, coupled relationships have been observed in which vibration from sound emissions have resulted in stimulation of accelerometers originally designed to track the motions of adjacent kinetic devices. Similarly, motion-based sequences designed to act in response to sensor stimulus tracking gestures of human occupants have been discovered also resulting from self-stimulation resulting from stray mechanical movements in adjacent mechanisms. Cycling patterns of feedback result, creating emergent behaviour.

Cairns-Smith's *Genetic Takeover and the Mineral Origins of Life*[21] have suggested that highly circumstantial couplings could well explain key relationships within the complex systems of organisms. By observing and analyzing the patterns of behaviour seen within the sentient canopy prototypes illustrated here, insight might be gained in ways that responsive architectural environments might relate to living systems evolved by natural processes. By coupling the kind of intelligent virtual models described here with their corresponding proprioreceptive dynamic physical environments, and by visualizing and analyzing the behaviours that they contain, increasingly complex hybrid relationships can become legible. These visualizations offer practical means for working with the systems indeterminacy that tends to challenge control of interactive systems by designers, and could help support skills for the rapidly emerging field of design of near-living systems.

[21] A.G. Cairns-Smith, *Genetic Takeover and the Mineral Origins of Life* (Cambridge: Cambridge University Press, 1982).

The physical fabric of this work is designed to pursue empathy embedded within the built environment. The oscillating behaviour of

Figure 7. Panorama of *Sentient Chamber*

architectural-scale immersive fabrics follow the alternating tracks of fear and attraction encoded deep within the limbic brain. Explicitly ambivalent and sentimental qualities offer immersive, enriched fields of expanded physiology. 'Blood' and 'soil' continue to be swept by repulsively violent nationhood, yet their unquenchable archaic origins offer prima materia for this fabric. The fabric reaches toward De Chardin's compelling hope: "prodigious sympathy might arise in material convergence."[22]

[22] de Chardin, 262.

Figure 8. View of *Sentient Chamber*'s various integrated layers, including synthetic biology, architectural structure and distributed sensing network.

On the dynamic relation between thought ontologies and materialised ontologies

Kathrine Elizabeth L. Johansson

The Socially Real and The Materially Real

– oscillations between (cultural) thought and matter

Technologically assisted arts bring forward new suggestions concerning the relationship between the human subject and material spaces, and intersubjective[1] relations at large. They can simultaneously be viewed as suggestions and presentations of new worlds. When Char Davies' installations *Osmose* and *Ephemere* demonstrated a completely new way of navigating the interface of a virtual reality environment, or when Philip Beesley's collaborative work, *Hylozoic Ground* presented a new prototype for a behavioural, connective architectural environment with yet unseen levels of responsiveness, they present new worlds, because they suggest a change in the existing cultural conditions for interaction and communication. In terms of architecture, if and when buildings gain behaviour and start to communicate and interact coherently with users and with the non-human environment, this very condition changes not only the cultural settings that we inhabit, it also changes the way in which we perceive the relationship between being and space. It generates different concrete experiences in the lifeworld. If metaphors arise from embodied experience, as Lakoff and Johnson originally suggested, it could mean that new metaphors will emerge, which, again could affect academic knowledge, even down to how we structure arguments and form theoretical input.[2]

If the techné of materialised worldmaking (which often triggers deviations from the established ways of understanding human perception, cognition and consciousness) thus gains a widespread influence, it presents a potential to change in our deepest conceptions of subjective becoming in spacetime and thereby affecting the process of creativity involved in staging worlds in accordance with our innermost desires and constituted knowledge. Due to the high degree of creative potential that lies in the use of new technologies today we are, to a greater extent than ever, immersed in a more explicit exchange between inner and outer worlds that also transgresses the division between the subjective and the inter-subjective. It seems that we are cognitively affected by the changes made at a cultural level at an increasing pace. It is therefore of the utmost importance that we are able to articulate and understand this change in society.

[1] The term "intersubjective" referring to levels that concern the interaction of multiple human subjects, most often at social scales, which is also reflected in the theoretical approach.

[2] Lakoff, George & Mark Johnson (1980) *Metaphors We Live By*. Chicago: University of Chicago Press.

There seems to be a developmental line in modern cultures between what comes into the (collective) mind as pure thought, which is then interpreted and culturally negotiated as academic knowledge, and what is subsequently brought into negotiation at the level of The Artefactually Real (the material realities that humans have created). This gives a kind of priority to personal and social thought at both subconscious and conscious levels, a concept which I find worthy of consideration in a time where retrospective causality, disciplinary fragmentation, and a static subject-object duality have otherwise been dominating. To study these relations does, in itself, provoke a questioning of the existing ideas about how we structure an argument. The bridging of these divides, when presented as a part of the writing structure itself, could cause confusion while reading this book chapter. It is, however, viewed as a necessary step to take in order to relate the dynamic connections between subjective, objective and inter-subjective positions. Let us start by addressing the problem of acquired knowledge versus knowledge as a mind altering experience – relating this division to the evolutionary development of human knowledge cultures.

Acquired knowledge versus experienced knowledge

In *Truth and Method* Hans Georg Gadamer presented the idea of experience as a mind altering event.[3] This means that insight changes us at our deepest foundation. Gadamer's perspective was pre-scientific, however, as it applied to methodologies in science and the humanities at large. Whereas Gadamer mainly focussed upon the individual human subject, the definition of knowledge cultures used in this chapter relies on an inherent evolutionary paradigm that incorporates intersubjective levels. The development of human knowing is thus understood to be based upon collective consciousness, and the kinds of mind altering experiences that can cause mutations in the mind of a whole culture. The state of the art of constituted knowledge, then, is viewed as an oscillation between institutionalised research and common sense understandings, based on a function of gradual assimilation that follows everytime new collective experiences are being made. What is important to add here is that today, what Bruno Latour named "inscriptions"[4], and what can be understood

[3] Gadamer, Hans Georg (2004): *Truth and Method*. London. New York. Continuum Books.

[4] To Latour, the instruments used forms a part of the research setting, and become somewhat directive of the results gained, and the further interpretations made.

as technological instruments, are implemented in all kinds of scientific observations, and thus become part of the assimilation of new knowledge, which therefore deeply affect the knowledge culture. The implications are profound with the integration of the digital computer, nanotechnologies, and newer biotechnologies.[5]

To sum up, we can say that just like an individual human subject can be understood to be in a state of constant becoming, so can a knowledge culture.[6] The process always involves moments of transition where "acquired knowledge" becomes "assimilated knowledge", where experiential insight is knowledge that is assimilated, and therefore in no need to be articulated or defined any longer. Today, this transition has changed pace to one with a much higher tempo.

The formation of technologically-assisted interactive arts most often involves collaborative processes of co-creation, based on a myriad of diverse skilled practices. In the case of Beesley's *Hylozoic Series*, skills within the fields of design, engineering, electronics and computing, synthetic biology, architecture, and philosophy are used.[7] The skilled practices involved can be viewed as references to the most profound knowledge units that characterise existing culture, including the level of technological development. In this sense the work can be understood to deliver a highly actual condensed reference to the developmental stage of the signification sphere, in which it is embedded.[8] We can therefore learn something about the conscious state of the signification sphere by looking in some depth at these artworks.

[5] Latour, Bruno; Woolgar, Steve: (1979:) Laboratory Life. *The Construction of Scientific Facts.* Beverly Hills: Sage Publications.

[6] My idea of knowledge cultures is inspired by Brier, Gadamer, and the development of the PhD-thesis, *Subject and Aesthetic Interface – an inquiry into transformed subjectivities.*

[7] Beesley, Phillip (2010): *Hylozoic Ground. Liminal Responsive Architecture.* Zürich, Riverside Architectural Press.

[8] Signification sphere is a term developed by Søren Brier (2008). It means the totality of sign expressions made on behalf of the inhabitants "umwelt" experience (Üexkull). A signification sphere can have a contingent demarcation line.

States of subjective vs. intersubjective thought

That in itself, however, does not tell us about the complexity of inner, idiosyncratic processes of the individual, and of how these relate to intersubjective functionalities of shared and negotiated language, when it comes to something such as insight, and the desire to create and communicate – which would necessarily lie behind the dynamic relationship between thought and manifestation at the material level of culture. Therefore, at the level of the individual, a distinction is made between:

1. A deep sense of self[9] that is, to some extend, ahistorical, and

2. A state, based on immediate intentionality connected to navigation and interaction at the cultural level, made on the premises of the existing culture[10].

The deep sense of self involves idiosyncratic properties based on a complexity of communicating systems internal to the individual, and the interpretations of truth made on this level. The deep sense of self presents a potential to get into contact with elements of The Virtually Real. The Virtually Real does not refer to digital virtuality, but rather represents a level of reality, which is not directly available to the gross human senses, but is potentially available to conscious, cognitive processes of thought, or extra-sensory perception. Intersubjective functionalities, on the other hand, involve the autopoietic mechanisms of socio-cultural interaction (inspired by Niklas Luhmann's *Social Systems Theory* and Søren Brier's *Cybersemiotic* theory[11]), language games (Brier with Wittgenstein), and the state of the arts of The Artefactually Real (the level of development in technologies and artefacts), where we can ask: which thoughts are implemented in the artefacts of a culture? And how do they become evident?

There is never a one-to-one relationship between subjective idiosyncrasies and social communications, although sub-conscious collective thought can be more or less intersubjectively connective in its pure quality (which, in relation to Brier's framework, could be described as a kind of collective phenosemiosis[12] - or shared pure feeling). Therefore, there can be commonalities in social consciousness at both conscious and sub-conscious levels, and at levels of non-negotiated, pre-intellectual knowledge. It is at the non-negotiated, pre-intellectual levels that individual minds can transcend into the collective, and share non-articulated experience. This level of shared consciousness is not presently taken into account in academic literature.

The point made in this section is that individuals can reach a reality of real objects from internal levels, which can also be a shared experience, because of the collective potential of pre-intellectual thought.[13]

Furthermore, we must realize that there is never a one-to-one relationship between thought in its purer form[14], and semantic levels of socially

[9] The deep sense of self resembles Husserl's state of individual transcendentalism, however is accounted for in more complex detail, and related to a contemporary setting.

[10] When I write of knowledge cultures, one level of a border, which would distinguish a knowledge culture from another is historical time. Others could be, but does not have to be, national borders, geographical borders, or specific knowledge domains. However, the potential of distinctions made is contingent. In the spirit of Deleuze and Guattari, the distinction is made solely to serve its focal purpose.

[11] Brier, Søren (2005): *Cybersemiotics - why information is not enough*. Canada. University of Toronto Press.

[12] *Phenosemiosis* is a term which Brier (2008) derived from the inspiration of Husserl and Merleau-Ponty's phenomenologies, in combination with the concept of semiosis. It means pure phenomenological experience and the way it is signified within the mindbody.

[13] This has similarities with Kant's transcendental state, however, is not equal to it.

[14] In line with the philosophy of Peirce, "thought" can be found both at pre-intellectual and at intellectual levels. "Pure thought" would be pre-intellectual.

negotiated knowledge[15]. Although this statement brings wide consequences with it, the important point is that there would always be levels of individual/collective thought that show an inherent potential to be negotiated as language-based intellectual thought, before there is a potential for it to be transformed into habits at the level of The Socially Real or The Artefactually Real. Such a relation shows a time discrepancy between pure intellectualised insight and the possibility of material manifestation.

[15] The concept of socially negotiated knowledge implies a level of constructivism, when it comes to an understanding of science and the humanities, that does, however, acknowledge a reality outside of human minds.

Levels of reality

I have now mentioned the Socially Real, the Artefactually Real, and the Virtually Real. But what are these reality levels, and where do they come from?

The Artefactually Real is a level of reality, which takes its point of departure in human made material realities (it relates, but is not equal to, Aristotle's concept "techné"). The Socially Real is a level of reality that concerns stable structures, systems and mechanisms at the social level (it relates, but is not equal to, Aristotle's concept "phronesis"). Both concepts were defined by sociologist Kate Forbes-Pitts who in *The Assumption of Agency Theory*[16] formed a levelled reality, partly inspired by Critical Realism and Roy Bhaskar, and partly by the business theoretician, Fleetwood.[17] Forbes-Pitt's theory of "assumption of agency" operates within deeper ontological levels than have been known recently in the field of sociology. However, the explicit use of ontological reality levels described in this chapter, are not equal to Forbes-Pitt's definitions. This chapter is explicitly concerned with The Virtually Real, which in Forbes-Pitts book relates directly to interaction with digital, computational interfaces. In this chapter The Virtually Real concerns any aspect of Nature that must be understood to be intangible, but which generates effects on the tangible levels of reality. The Materially Real, on the other hand, refers to all tangible parts of Nature, which have not been formed by humans. Forbes-Pitt's further operates with a level of reality, which she calls The Ideally Real. The Ideally Real relates to pure mental representation, which is closely connected to intentionality and agency. While the concepts in this chapter do not operate with The Ideally Real, the use of these ontological levels of reality will become more explicit as the chapter progresses.

[16] Forbes-Pitt, Kate (2011): *The Assumption of Agency Theory. A realist theory of the production of agency.* Oxon. New York: Routledge.

[17] Fleetwood, 2005.

Ontological speculation has long been a taboo in many academic settings. But a society that has forgotten the ability to speculate creatively at deep existential levels, outside of existing language games and institutional paradigms, will have difficulties integrating and negotiating new levels of thought, and implementing them into The Socially Real, and cannot be truly creative.

Thought ontologies

When it comes to ontologies that are first and foremost based on mediation of pure thought into intellectualised language, creative installations can, besides from concrete changes in the relationship between becoming and developments of urban spaces, alter our self-conceptions as human subjects at deeper levels. Human self-observation, as related to the formation and existence of knowledge cultures touch upon ontological views at the philosophical level, is concerned with our deepest understandings of space, time, being and becoming.

The question of human subjectivity and consciousness in relation to the philosophical question of how we know, forms a central point of interest in the work presented here. The foundation of how we know must be understood to base itself on perception and cognition, which synthesises into states of consciousness, and, of course, which relates to objects (tangible and intangible) in Nature. This results in a level of contingency that implies a constructivist point of departure. The integration of a phaneroscopic[18] phenomenology, as presented by Brier with Charles Sanders Peirce, however, allows levels of reality that exist outside of human realms of knowing. In this way of regarding reality, we are always approaching real objects through different kinds of signification, and the point of departure changes from constructivism to pragmaticism.[19]

The functionality of art installations does more than adding to, and developing, the socio-cultural signification spheres at the level of The Artefactually Real. It also evokes attention towards central ontological questions that are becoming more and more urgent, while our place in a changing world seems increasingly uncertain, and we experience how common social realities are disrupted (existing paradigms dissolve and transform, the finan-

[18] Peirce defined his philosophy as "phaneroscopic" relying on a triadism that involves a continuity between firstness (pure feeling), secondness (pure relation), and thirdness (mediation between the two), which forms the deep ontology of his philosophy.

[19] *Pragmaticism* is Peirce's version of pragmatism (Brier, 2008).

cial system cracks, political systems are in transformation, and the climate crisis forces a new view upon the human-Nature relationship).

A concrete speculation combining a reading of a piece in Beesley's *Hylozoic Series* with the question "what is life?", can illustrate the oscillation between thought ontologies and material ontologies, and specify how art as research can contribute at both levels.

The Hylozoic Series – the becoming of an architectural prototype

The *Hylozoic Series* by practitioner of architecture and digital media art Philip Beesley presents an overall architectural prototype that is expressed in a number of versions from 2008 till present. The *Hylozoic Series* distribute new levels of responsiveness by integrating new generation artificial intelligence and synthetic biology. *Hylozoic Ground* represents one version in the *Hylozoic Series*, which was exhibited at the Venice Biennal in 2010. Because questions concerning the borderline between abiotic and biotic life lie implicit as a part of the design of the installation,[20] it forms an excellent background for speculations concerning life and consciousness. Not least because the work was, by Riverside Architectural Press claimed to be "nearly alive".[21]

Hylozoic Ground is based on the creative use of lightweight fabric, and the construction of a geometrically patterned "mesh" and skeleton, in which microcontroller, actuator, and sensor technologies give the sculpture a range of responsive behaviours. The first versions of the sculpture were based on dry (meaning not involving liquids), mechanical technologies, whereas later versions have incorporated the science of synthetic biology in the form of artificial cell like compounds, some of which are sensitive to carbon and moisture in the surroundings, and which run their own developmental processes as the installation is exhibited. It is obvious that the sculpture is an artificial text (part of the Artefactually Real) that finds its core inspiration in the bio-text (part of the Materially Real)[22]. To play with the generation of features that are understood as central, when it comes to bringing matter into "life", involves deep ontological questions about what life is per se. Therefore, the sculpture has references in its very design to processes that are representative of some of the current and

[20] Beesley, Phillip (2010): Hylozoic Ground. *Liminal Responsive Architecture.* Zürich, Riverside Architectural Press (pp. 136-141).

[21] http://www.riversidearchitecturalpress.com/current_publications/hylozoic_ground/index.html. Date of access: June 6th, 2013

[22] In order to make comparative observations and draw important distinctions between two rather different phenomena, the common frame that binds the artwork and the biological organism together is the concept of "text".

dominating understanding about what constitutes a living organism and of scientific areas preoccupied with questions concerning the living. Some of the bodily processes that are understood to have inspirationed the artworks are: respiration (air is pumped into and circulated within the internal system of the sculpture), the hormonal system and the blood system (hygroscopic islands), the nervous system (the overall electronic system that connects sensors, activators with micro controllers and central circuits), muscle fibres (the cut of parts of the polyester), the skeleton (geometric construction of the hard part of the architecture), cellular respiration processes (synthetic cells, which react to carbon dioxide and moist from the user's breath), and metabolism, where the sum of all parts and their mutual exchange form the behaviour and identity of the overall sculpture. Homeostasis and equilibrium seem represented by the inbuilt memory alloy, which allows the sculpture to regain its position after activation.[23]

[23] These are my interpretations after having experienced the sculpture at the Ars Electronic Museum in 2010, and from insight gained particularly from Beesley, 2005 and 2010.

The installation demands user interaction and participation. Its own internal processes, which are mainly based on electronic and digital technologies (Arduino hard- and software, combined with a hard wired setting) and chemical compounds, are fairly weak without user interaction. The sculpture is, however, sensitive to the atmosphere of the exhibition space.

The work is based on the constant development of new elements, and the refinement of existing elements, which are gradually embedded into the sculpture. The latest element is synthetic biology. The *Hylozoic Series* is then in a constant state of becoming, attaining more refined levels of internal connectivity and external responsiveness. This gives an original input to the realm of architecture, and the development of contemporary and future urban spaces. It also gives an invigorating provocation to the speculator, seeking new answers to questions concerning the role of motion and communication in living organisms, and how this might relate to consciousness.

Biosemiotics and Cybersemiotics as useful paradigms

It has been common in Western, scientifically based knowledge cultures, to understand consciousness as an epiphenomenon of the brain, and to understand its by-products as more or less non-related to physical reality – philosophy had nothing to do with biology. Simultaneously, biological mechanisms and functionalities have been understood as random, and as non-connected to thought processes and processes of language generation and language use in the human subject.

Biosemiotics is a relatively new field of biology that takes a first step in mending the divide between physiology and mind. Biosemiotics was developed under inspiration of Jakob Von Uexküll and later on Thomas Sebeok, who suggested a combination of biology and semiotics on the background of the philosophy of Charles Sanders Peirce.[24] Biosemiotics connects elements from the human and the natural sciences through the paradigm of Peircean semiotics. Peirce's doctrine of signs adheres to a central idea of triad semiosis[25], where a sign always refers to a real object, and where the process of interpretation is called the "interpretant". Peirce operates with ontological causalities similar to those of Aristotle, one of which is "final cause". Biosemiotics takes up an evolutionary, process oriented viewpoint, and accepts Aristotle's "final cause" as "goal direction" in both cultural and biological sign processes.

[24] Today there are two main schools, one in Tartu, Estonia (Kalevi Kull, et.al.) and one in Copenhagen, Denmark (Jesper Hoffmeyer, Claus Emmeche, et.al.) Hoffmeyer, Jesper (2008): *Biosemiotics: an examination into the signs of life and the life of signs.* University of Chicago Press.

[25] Triad semiosis consists, to Peirce, of a continuum between "representamen" (the sign as it appears), its "object" (to which the sign refers), and the "interpretant" (the meditation between the sign and its object, and the sign it generates in the one who meets the sign).

Søren Brier's cybersemiotic theory (2008) delivers an even more complex account of a way in which to understand processes of autopoiesis and semiosis at levels that integrate the biological, the phenomenological and the linguistic process in one, overall model. The concept of cybersemiotics, and the way in which it suggests to view processes of cognition, communication and consciousness in and between human subjects, does not present the same fragmented separation of parts, which we are accustomed to in most other academic fields. Thus, with biosemiotics and cybersemiotics, new steps are being taken that connect organic and mental levels of being, learning and knowing. This gives an altered starting point, when seeking to define consciousness in living organisms. Consciousness is no longer just mental and upheaved; it also has physiological affiliations.

I find that a hermeneutical-semiotic approach[26] to a sculpture such as *Hylozoic Ground* can provoke questions towards existing self-conceptions, and force us into explanations that tie biology, physics, psychology and social relations together in new ways. Furthermore, it gives us a vocabulary when reading symbolic levels of the sculpture, and adding

[26] An approach that combines a hermeneutical approach with a semiotic one – concentrating on interpretation and sign reading.

to our proposition concerning the question "what is life", that we do not have to let concepts from physics or biology be ontologically dominant. Rather, we can constructively add elements from each of these fields. In the analysis of *Hylozoic Ground*, concrete and symbolic sign levels are combined and brought into an overall philosophical contemplation concerning life and consciousness.

Artificial Life and biomimicry

One way of reading *Hylozoic Ground* is to focus particularly on the element of synthetic biology and the way that this chemistry integrates with the electronic and digital levels of the interface. This reading aims to form an examination of how concrete and symbolic levels of the interface deliver potential meaning. This can be combined with a thematic focus upon Brier's (2008) main thesis that it takes a combination of cybernetic-autopoietic and semiotic processes to generate communication in and between organisms, and in the end: consciousness and life. For the purpose of this discussion The *Hylozoic Series* are treated as a series of texts that present a semantic structure that communicates through the signifying levels of material objects and functional processes in the sculpture. The assumption is that just like a philosophical text can present an exploration of thought, so can the art installation. Unlike the philosophical text, the art installation is not reliant on verbal or written language for the construction of concepts. The art making process could be understood to oscillate between pre-intellectual and intellectual thought, most often assisted by words (for instance in an artistic concept or manifesto). But the full range of the thought process is most usually expressed in a material creation, which integrates its elements in a complex, ambiguous, non-realistic, and often anticipatory syntax.

On a cultural level, themes of Artificial Intelligence and Artificial Life have provoked changes in previous definitions of cognition, intelligence and consciousness. The debate has primarily been based upon experiences made in the realm of computing. It has concerned the connection between digital code and the interface level. Synthetic biology is a new discipline within the fields of chemistry and biology, which attempts to creatively generate chemistry with life like properties, however is not necessarily based on imitating cells or molecular structures of life in any one-to-one manner. This discipline makes the question of what constitutes the living more urgent, and can also function as a mirror on regular biology. Not by imitating the field of biology, but by exploring and demonstrating other ways of using knowledge of biological life, and placing ideas of biological functionality into contexts that are very different to that of natural bio-texts.

What is interesting on a philosophical level is the fact that even if both artworks and projects of synthetic biology seek to avoid mimicking biological materiality in any kind of exact reference, when presenting text forms that are different from such of real organisms, the constraints involved while seeking to present a given functionality seem to make more or less direct reference to constraints involved in the self-same processes of living organisms; or at least to ways in which we are able to contemplate such. Reconstructing functionalities of biological organisms in artificial textural forms creates an alienation effect that can provoke new thoughts on how to understand the nature of these functions. It can also highlight the limitations of existing knowledge of the living organism. If the artificial representation of these functionalities reveal characteristics of the constraints (Peircean secondness) involved in natural habits, we can say that there is a mimetic relation between the functionality of the artificial text and the functionalities of the materially real, which has inspired the artist. This implies that there are real virtual objects behind the functionalities demonstrated.

The relation between functionality in artificial texts and natural habits can be philosophically accounted for by Peircean ontology. Peirce places a continuous relation between firstness (pure quality with a tendency to take habits), secondness (constraints, physical forces, etc.), and thirdness (manifestations based on mediation between firstness and secondness). Thus, there would be no habit without constraints or resistance involved. And this resistance causes regularities, which, again, relate to habits of Nature, to form. Some functionality known from the study of biological organisms, could, in fact, be representative of similar resistances and habits, and they manifest as one seeks to mimic the respective function by forming a structure in a relational, dynamic, material context. The point here is that functions of artificial texts are not arbitrary. They are rather indexical of real virtual objects.

Based on this background of ideas, I would like to speculatively suggest that the imagination always works under primary constraints implicit in The Virtually Real and The Materially Real (which is most directly connected to habits of Nature), and the secondary constraints implicit in The Socially Real and The Artefactually Real (which is indirectly related to habits of Nature).[27] It is particularly the constraints with a primacy at the level of The Virtually Real that have been avoided, and negated by modern science, with the positivistic claim that the content of the imagination is not realistic. This has been so, because the virtual realm is intangible, whereas science has traditionally sought to define tangible and positive experience.

[27] That is given that the functions of the imagination are not distorted at the level of intermediacy between the human subject and the surrounding levelled realities.

Acquainting the virtually real, however, demands a special kind of attention and skill. Furthermore, it is most likely that the connection between imagination and the different levels of reality, all of which function at different levels of emergence, needs individual refinement, exploration and training in order to establish clear connections. It is the clarity of the connection between the embodied mind and its specific conscious processes of sensation and cognition, and objects of the respective levels of reality, which form the foundation for truth. Truth is then relative to the idiosyncrasies of individuals, and must still be intersubjectively negotiated if it shall add to the formation of social structures or generalized knowledge. However, the potential of individual subjects gaining full clarity in intermediate relations is understood to be a fact. In this respect, truth still exists.

Testing knowledge by the creative process of art making

In the process of creating chemical compounds that generate life like properties, one consequence is that the researcher must necessarily question current assumptions within the field of biology. First and foremost because regular concepts of what makes up a chemical balance, or what makes an overall chemical process run, might not be based on the degree of randomness and "survival of the fittest" that we know from neo-Darwinism in mainstream biology. Even if we have computational power to mimic processes based on statistic properties and selection based on for instance stochastic or chaotic processes, and can understand and model ideas of such processes in extensive ways, this might not be enough to account for what really goes on in intra- or inter-cellular communications, or in cognitive processes of the organism at large. This does evoke questions of a philosophical kind. First of all, it does so because this is the experiential realm (where science is understood as an "experience" made by a knowledge culture) that has been put into a formula, which tells of prior academic experiences, concerning organic life per se. When artist researchers explore the creative and perhaps anticipatory ideas concerning biological knowledge, they simultaneously demonstrate and test this knowledge. The demonstration in a different material context (that of the artwork) could, potentially, evoke new experiences and thoughts on the same questions asked in biology and the philosophy of biology. The process of research in art making is based on completely different parameters than such of theoretical science or laboratory research. The aim is not exactness and repeatability, but functionality, use and a connective quality based on aesthetic ambiguity. Secondly, existing material and paradigmatic approaches, which have formed directions for biological research and theoretical biology, quickly become inadequate when it comes to finding solutions for the creation of chemical compounds with qualities or real cells (or as one generates a sculpture) where the relation of parts can demonstrate life like behaviour. Art research must therefore anticipate future situations, and design yet unforeseen connections.

As protocells are further worked into the "soil-structure" of the sculpture, and is sought to co-operate with its electronic functions within the complex, geometric patterns of its "skin"[28], the sculpture can communicate a much wider and more provocative narrative than an examination of a research process in a synthetic biology laboratory would have permitted.

[28] Spiller, Neil; Armstrong, Rachel (eds.), (2011): *Protocell Architecture*. John Wiley and Sons.

The problem of cybernetics and semiosis as approaches from a point of view of Hylozoic Soil

– A philosophical contemplation on the theme of bio-logos

By bringing Brier's theory into the picture, I am not only looking at the sculpture in a concrete manner, but rather I am investigating the idea of cybernetic and semiotic processes as a philosophical problem, and relating it to the concrete combination of electronic and chemical processes, which form an integrated part of the interface in The *Hylozoic Series*. I am thus addressing new symbolic levels in the artwork per se.[29]

[29] To connect the concrete level with the theoretical, it is obvious that I am reading the sculpture at the level of symbolic reference, where the references are mainly to be found within the realm of science and philosophy.

When it comes to an understanding of what could be the most central components in what makes something alive, we can look at Brier's claim that chemistry and self-organising properties belong to the area of information, which Bateson has further categorised as "a difference that makes a difference." Furthermore, Brier relates the level of information to the concepts of "signalling" and "pattern fitting", and thus to Peircean secondness, which again relates to Aristotle's efficient cause. These processes, however, have to have interpretants and be mediated, in order to gain the quality of triad semiosis (the continuity of representamen, object and interpretant). To Brier, chemical processes belong to the level of "pattern fitting", but they are not in themselves semiotic; and consciousness and life rest upon semiotic properties.

Brier's definition of information must be understood in relation to Information Science, with Norbert Wiener, Shannon and Weaver as main characters. This means that what is demonstrated in this sculpture at the concrete level, and read as symbolic references (the electronic system referring to a cybernetic system, and the synthetic biology compounds referring to chemical transactions of biological cells), and if we understand *Hylozoic Ground* to represent one confined organic structure, would have to be defined as secondness (pure relation). Because, naturally, the system cannot distribute self-maintenance, closure and open evolving exchange by itself. It is put into motion by the action of artists, and held active by the intervention of users. This is in contrast to living systems that perform actions either by themselves, or by forces that we are not able to classify as yet. There is an open question in biology at this point of which Biosemiotics, in part, seeks to solve by accepting the idea of biosemiosis and goal direction.

This reading of the sculpture indicates both the central influence of an overall electronic, information handling system, in combination with different kinds of wet, cellular solutions (tissues), when it comes to the function of responsiveness and empathy in an organism. At another level of symbolic reference, the way hygroscopic islands (wet, chemical solutions embedded in the hylozoic "mesh") are integrated into the fabric and functionality of the sculpture, does seem to refer to the hormone system (which functions in close relation to the blood system) where hygroscopic islands could be read as symbolically signifying hormonal glands, and their secretion, which is crucial to endogenous biological processes.

Beesley has declared that empathy forms the central concept behind the sculpture. This concept is broadened from a romantic notion (Wilhelm Worringer), to empathy as a physiologically embedded potential, defined by its responsive properties. If we allow ourselves to take our symbolic readings that far, connecting to associations that go naturally with the concept of glands and blood system, we move into the vocabulary of Brier, where he distinguishes bodily semiotic processes as biosemiosis, phenosemiosis (immediate, qualitative experience), and thought semiosis. This is how we could describe the interfaces between physicality, feeling, cognition and consciousness in order to understand empathy or responsiveness in ourselves as humans.

New understandings of consciousness

When it comes to biosemiotic and cybersemiotic theory (to which I connect my argument), we must remember that consciousness forms both a prerequisite for, and is embedded in, the living organism (as well as in the non-organic object). This connects Brier and Beesley well, since hylozoism in itself is built upon this very idea. This means that the process would have come into being on behalf of some kind of qualitative consciousness to begin with. And the way this kind of consciousness operates from within results in different levels of biological emergence, which generate an emergent kind of consciousness that can, again, become available to human day conscious interpretations. These interpretations would, in part, be made by the brain, and they would furthermore be interpreted into the languages of cultural semiosis – the sign systems by which we exchange at the cultural level. In this understanding, there would be many levels and ways in which consciousness operates in Nature. Consciousness, thus, needs to be defined in a much more complex and kaleidoscopic manner that allows a dialogue to open between the natural sciences and the humanities. It is my view that creative processes that integrate higher degrees of intuition, as in art practice and research can, on behalf of the sub-conscious elements involved, demonstrate new layers and levels of insight through the creative process. This is yet another reason why sculptures like the The *Hylozoic Series* can contribute to human knowing.

What holistic biophysics can add to the reading of The Hylozoic Series

If we move back into the symbolic level of The *Hylozoic Series*, the idea of a global, electronic system that processes, distributes, translates and stores information, and that demonstrates the importance of intelligence being viewed as a globally distributed phenomenon, this evokes thoughts concerning how we could overcome the current focus on intelligence as a left brain logical activity. We begin to understand that many units and networked processes in the bodymind must necessarily be intelligent in themselves in order to make the system run. The wide distribution of information handling units and logical processes seems necessary within a system that could demonstrate life-like behaviour. This is so even if there are of course boards that take care of higher level global complexity throughout the overall system. The dimensions that lie implicit in the idea of a global electron conduction system connect, perhaps iconically (which distributes likeness) to the frameworks of Mae Wan Ho[30] and James Oschman.[31]

[30] Ho. Mae Wan (2008): *The Rainbow and the Worm.* Singapore. World Scientific.

[31] Oschman, James (2001): *Energy Medicine - the scientific basis.* London. Churchill Livingstone.

Wan Ho and Oschman each explain biological processes as being dependent upon a post-molecular state of emergence, which relies mainly on global electron and proton conduction in crystalline, gel-like, water arrays, which are abundant in extra-cellular tissues of the organism. They explain this information handling system with concepts from physical science, such as: "entanglement", "non-locality" and "wave interference patterns". This includes sound in the form of "phonons", and light in the form of "photons".[32] These properties run by their own emergent regularities, however tie centrally to the global electronic systems of the body. If we relate this to Brier's cybersemiotic problem, we would have to say that it is only as information at this level is "interpreted" in an intermediary sense that we can talk of triad semiosis. For now, I cannot argue whether, or how, this would happen at the biological level. However, between the kinds of semiosis that Brier suggests, it makes sense to expect an intermediary exchange between biosemiosis, phenosemiosis and thought

[32] Ibid.

semiosis. This brings philosophical thought functions, such as for instance pre-intellectual and intellectual thought, in direct relation to physiological processes of the bodymind.

The idea of biophysical equivalences to consciousness in organisms, upon which Oschman and Wan Ho largely agree, transgresses current assumptions concerning philosophical ideas of consciousness, and connects mind and matter much more tightly. At the same time, with Brier, we escape the overall functionalist and mechanistic approaches of cognitive science, which rests largely upon the paradigm of Information Science. Brier brings "mediation" and "meaning" into the picture at all levels of the organism, and of reality. The level of quantum connectivity in both Oschman and Wan Ho, indicates a level of consciousness that forms an intersection point between consciousness and physicality, and presents an intriguing moebius strip problem, which concerns the problem of making a division between internal and external states of being, connecting the singularity of the organism with states of collective consciousness, the nature of which is, in my view, not yet fully understood.

The *Hylozoic Series*, at both concrete and symbolic levels, distributes properties of one side of Brier's model, which is that of cybernetics based on autopoiesis theory, but lacks that of triad semiosis, unless we move far into a hermeneutical interpretation and add the elements ourselves. This, of course, would partly rely on the fact that we have not invented a computer that operates on the basis of principles of "the triad", but only on principles of "the binary", and because Rachel Armstrong's three kinds of synthetic compounds do not present triad semiosis as they evolve and connect with the environment. Naturally, it would be no request for a contemporary sculpture to add the whole range of elements, even at the symbolic level. The study of the sculpture is solely made in order to provoke existing thoughts concerning how we can define traits that are central in living, conscious organisms, as opposed to non-living organisms (the last of which has its primacy in the domain of The Materially Real).

It makes a difference to experience the inspiration of autopoiesis theory in materiality (even if it is partly concrete, partly symbolic) rather than in theory alone. The artwork makes it possible for users to follow the artist's thought process in an immersive interaction with a material manifestation.

The phenomenological experience of real life materialities which are thought into immersive function at the level of the interface, provoke other lines of thought than for instance print theory or oral explanations alone. This statement brings us back to the central question of what makes organic matter different from non-organic matter. If non-organic matter can also be conscious, then what is the difference between consciousness in the living, and consciousness in the non-living? Adding semiotic processes, networks of interpretants within the scheme of the electronic systems, would move closer to Brier's conception of what makes an organism conscious and living, and it would open up for an approach of defining more specifically the properties that machines and artificial systems cannot live up to, as the question of what separates man and machine is asked again. It, thus, is all about ways of communication, ways in which triad semiosis happens in an integration of many simultaneous processes, which work, however, at very different time scales, most possibly also with high degrees of complexity what the issue of spacetime is concerned. The complex symphonies of multi-levelled processes, each distributing a range of different spacetime properties, all suggest a multidimensional orchestra, based on qualities of pure consciousness, of which we still know very little, if anything about.

When we read the sculpture, we have the opportunity to move further than explanations of biophysics or bioelectromagnetics. We can add the perspective of Brier, and claim that neither thought, nor pure feeling can be described adequately by concepts from either physics or biology. But physics and biology can certainly add to the story. And the use of these areas of enquiry, rather than mere philosophical concepts, allow us to view a transfer of the vocabulary that indicates a transformation of what formerly showed up solely at the level of thought and reason in Western signification spheres, and which was, for a long while non-provable at the level of materiality (most centrally because of the scientific instruments available), can now be measured and demonstrated at the material level.

Conclusion

The detection of how thought today lies behind verbal and material manifestations rests upon the way we are able to form epistemological narratives based on understandings of both the collective sub-conscious and the constant development of thought and signification spheres at large. This chapter aimed to pull together art communication and philosophical speculation in order to demonstrate a way in which contemporary human knowing can feed from such a relation.

Whether thought comes before artefactual reality is not always easy to clarify, when it happens at the social level. Technologies and techné as worldmaking, also affect cognitive patterns,[33] and provoke new metaphors and crucial terms, which can potentially end up as catalysts of further theory production. Therefore, it seems fair to say that there is a connection that functions in mutual loops, rather than in linear causalities, between wordmaking as techné through art, and worldmaking through words and speculation, and which, furthermore, is unevenly distributed at intersubjective levels. The complexities involved in real life biological organisms versus the complexities of technologically assisted art worlds, and the on-going relation where one informs the other, also tells us that we must be cautious with explanations that places the dominant ontologies at the level of the physical-material world (where machine metaphors inform concepts of mind), when it comes to explaining our biology and human identity at large.

[33] Hayles, N. Katherine (2012): *How we think.* Digital Media and Contemporary Technogenesis. Chicago: University of Chicago Press.

Furthermore, the discussion in this chapter has sought to demonstrate the complex, but creative, potential that lies in a faster connection between conceptual thought and material manifestation at the cultural level. Here it becomes central not only to be reflexive, but to focus upon expanding our self-understandings (also in academia), into increased awareness of how we form our knowledge cultures, and how we form the signification spheres in which we are immersed. This demands a responsibility that can only be taken seriously if we accept our roles as co-creators of our complex cultural surroundings. The Artefactually Real is the world of human creation. In my view, we have a responsibility both when it comes to forming artefactual realities, but also when it comes to forming signification spheres, in the most optimal form of which we are capable. Therefore, we need to ontologically re-acquaint ourselves and our common significations and interpretations of the Nature in which we are embedded, and from which we derive the insight and material to form The Artefactually Real.

Towards a Genealogy and Futurology of Art and Technology: New Media, Contemporary Art, Collaboration

"It is not guilty pride but the ceaselessly reawakened instinct of the game which calls forth new worlds" - Heraclitus

Edward Shanken

Introduction: Historical notions of Art and Technology, and the Relationship Between Them

Art and technology have been paired together throughout western intellectual history. The concepts signified by these terms have varied widely, and the relationship between them has been subject to much debate. Contemporary notions of art or technology are markedly different from those shared by Plato and Aristotle, who made no distinction between what are now considered the fine arts and the applied arts. The ancient Greeks did differentiate between the liberal arts and the servile arts, though both were subsumed under the rubric of τέχνη (techné). The division between these arts was based on class distinctions and related attitudes towards different types of skills: the liberal arts (such as logic and rhetoric) required intellectual reasoning and were deemed suitable for free citizens, whereas the servile arts demanded manual skills, such as metalworking and painting, that were performed by slaves or members of the lower classes.

According to Aristotle, techné enables what is to be produced to come into being in the absence of reason or judgment. He argued that the virtue of praxis, which is the special work of humankind, cannot be reduced to techné[1]. Plato condemned art for its exclusive concern with appearances or, more precisely, the appearance of appearances. However, the mimetic standards by which painting and sculpture were judged by the ancients included not only their ability to imitate the appearance of things, but to evoke states of mind and dispositions of character through psychological association[2]. Roman accounts went further, attributing wisdom, intuition, and imagination to art. Descriptions of Pheidias' sculpture by Cicero and Philostratos, for example, recognized not only the skillful, mimetic reproduction of appearances that can be seen, but the representation of the nature of beauty itself, a quality that could be envisioned only through the imagination. Thus the Roman understanding of art further elevated its status above that of mere craft.

The source of contemporary distinctions between science, technology, and art has been credited to Artistotle's parsing of theoretical, practical, and creative goals: truth, praxis, and making, though the origin of these contemporary distinctions is not nearly so neat[3]. For example, art and

[1] John Phillips, "τέχνη's Other Eye: Concerning an Art with No Effects," in John Gange, ed., *Art, Technology, Technique*. (London: Pluto Press, 1998): 51-2.

[2] J. J. Pollitt. *The Ancient View of Greek Art: Criticism, History, and Terminology.* New Haven: Yale University Press, 1974.

[3] Barbara Becker and Gerhard Eckel, "Zum Verhältnis von Kunst und Technologie - dargestellt am Beispiel der zeitgenössischen Musik", in Bernd Wolfinger, ed., Innovationen bei Rechen- und Kommunikationssystemen. (Springer: Berlin 1994): 488-491. Reprinted in English as "On the Relationship between Art and Technology in Contemporary Music", *Research Report, GMD, St. Augustin*, 1994. Published online at < http://viswiz.gmd.de/~eckel/publications/becker94c.html>.

technology were closely aligned in the creation of religious architecture in the Middle Ages and mathematics, architecture, and art were inseparable in the formulation of the rules of one-point perspective in the Renaissance. The Renaissance also brought a significant reappraisal of the status of art in the hierarchy of human endeavors. Artists became highly regarded in the court and church, and their works became more highly prized.

In the mid-eighteenth century, French philosopher Abbé Batteux's concept of *beaux-arts* contributed to distinguishing the fine arts from the applied arts[4]. Synthesizing this distinction with the Aristotelian division between theory, practice, and making, Denis Diderot's *Encyclopédie* was divided among the sciences, the mechanical arts, and the fine arts. Diderot's recognition of painter Jacques Louis David as an "*artist-philosophe*" further manifested a blurring of the ancient distinction between the liberal and servile arts with respect to painting. In 1750, German philosopher Alexander Gottlieb Baumgarten coined the term "aesthetics" (*Ästhetik*), establishing a branch of philosophy that would apply the tools of reason to theorize perception of the beautiful, including the beauty attributed to the arts. While Enlightenment aesthetic values have been challenged by the discourses of experimental art throughout the twentieth century, even in the early 2000s, popular notions of what constitutes art and its role in society remain closely attached to eighteenth century ideas.

[4] Abbé Batteux, *Les beaux arts réduits a un même principe* (1746).

By contrast, the idea of technology (in the broad sense of how the word is used today) did not emerge until relatively recently. From the mid-eighteenth to the late nineteenth century, terms such as the "mechanical arts" commonly referred to various applied arts, including those that used machines (such as the power loom) to facilitate production. According to historian of technology Leo Marx, prior to 1880 the term "technology" was seldom used, and then only when referring to a scholarly study of the mechanical arts, such as a treatise on weaving techniques. Just as the ancient distinction between the liberal and servile arts established a hierarchical opposition, so the habit of distinguishing between the fine arts and the mechanical or practical arts inculcated a set of value-loaded discriminations between ideas and things, the mental and the physical, the ideal and the mundane, and so on. Such distinctions had the effect of denigrating the practical arts while elevating the fine arts by comparison[5].

[5] Leo Marx, "The Idea of 'Technology' and Postmodern Pessimism," in Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History: The Dilemma of Technological Determinism.* (Cambridge: MIT Press, 1994): 237-257.

The advent of the more abstract and neutral term "technology" in the latter part of the nineteenth century disrupted this categorical distinction. According to Marx, "technology" came into parlance at a moment when the notion of the mechanical arts, as embodied in the discrete machines (such as steam engines) that initially fueled the Industrial Revolution, was being replaced with a grander and more integrated conception of transportation systems, communications networks, and a decentralized notion of power production and distribution. This description suggests that the term "technology" carried with it a proto-cybernetic sense of systemic interconnectedness.

By the time the contemporary sense of "technology" gained wide currency in popular parlance after World War I, it carried few if any associations with the specific materials, artifacts, classes of labor, locales, or institutions of the applied arts, and their *déclassé* connotations of grease, sweat, steel, and vast, smoke-belching machines[6]. Technology, by contrast, suggested highly integrated systems that were clean, upwardly mobile, corporate, and immaterial. The inclusiveness of technology begged an adjectival modifier: bio-, nuclear-, information-, and so on. Due to this indeterminacy, and given its claim on the legacy of the Enlightenment notion of scientific progress, "technology" often has been imbued with all manner of metaphysical qualities as a causal agent of social change, and indeed, history itself[7].

[6] For more on the relationship between technology and spiritualism in late nineteenth-century art, see Christof Asendorf, *Batteries of Life: On the History of Things and Their Perception in Modernity.* Berkeley: University of California Press, 1993.

[7] Marx, op cit: 249.

In the following discussions, I use the term "technology" in its common, broad, indeterminate sense, with a range of material, conceptual, and mechanical characteristics ascribed to it. Indeed, given the historical weddedness of the fine arts, the applied arts, and technology, they share a common if tenuous connection with materiality and apparatus. All or nearly all fine art has been and continues to be technological on some level, for artists have always relied on materials, tools, and techniques to practice their craft and fabricate artifacts. However, these materials, tools, and techniques must not be thought of as constituting something pre-existing, autonomous, or external that is then applied to the practice of art-making; for technology is as much the result of artistic practice as works of art are the result of the application of technology. In Lewis Mumford's words, there is a "reciprocal relation between art and technics.... Even the most cursory historic survey of the arts reveals a fertility of invention in design unsurpassed by any utilitarian equivalent in engineering until the nineteenth century."[8] In order to avoid the unwieldy syntax necessary to maintain an acausal understanding of the relationship between art and technology, statements that impute autonomous agency to either art or technology should be interpreted as shorthand for lengthier and more detailed descriptions that acknowledge their hybridity and dependence on a wide range of social factors.[9]

[8] Mumford, Lewis. *The Myth of the Machine: Technics and Human Development*. (New York: Harcourt, Brace, Jovanovich, 1966): 254.

[9] This model is derived from Jay David Bolter and Richard Grusin, *Remediation: Understanding New Media* (Cambridge, MA: MIT Press, 1999): 75-78.

Indeed, technologies developed primarily by artists in the context of solving artistic problems have contributed to major transformations in the history of art and culture. The invention of oil-paint in the late Gothic period sparked nothing less than a revolution in painting. The development of one-point perspective in the Renaissance by artist-engineers was a tremendous technological achievement that has arguably had an even greater impact on the history of art and perception.[10] Through its reification in the technology of photography, perspective has become even more firmly entrenched as the social standard by which the representation of spatial realism is measured. But it must be remembered that perspective, and its recapitulation in photography, are mathematical and technological abstractions, and only approximate human perception, which is not precisely linear, possesses blind-spots, and so on.

[10] As McLuhan has noted, one-point perspective was also inextricably bound up in the economic shift from a feudal system of indentured serfs to a mercantile system of self-serving entrepreneurs. See, *The Gutenberg Galaxy*. Toronto: University of Toronto Press, 1962.

These particular examples offer insight into a further aspect of technology as it relates to art, an elusive component that I claim is predominantly conceptual. Located between the messy materiality of oil paint and the precise, mechanical apparatus of photography, perspective is a particular instance of a technology (in the contemporary sense) that emerged from and became central to artistic production. It predates the nineteenth century emergence of "technology" as distinct from the specific materials and mechanical apparatus of the applied arts, yet perspective is itself immaterial and requires no physical tools. In this regard, it has much in common with a central technology of the Information Age: software. Like software, perspective operates behind the scenes like a visual operating system, so to speak, organizing perceptual information according to a programmatic set of instructions.

The use of science and technology in art is not limited to materials (e.g. paint), concepts (e.g. perspective), and machines (e.g. photography). Artists have incorporated cybernetics, chemical reactions, artificial life, and many other components in their work. Such elements do not fit comfortably within the framework of materials, concepts and machines, and a more exhaustive scheme for differentiating amongst the characteristics of artists' use of technology would lend greater precision to its understanding. Moreover, it must be noted that these categories are not mutually exclusive; rather, they each tend to contain aspects of others. This feature is important because much criticism of the artistic use of technology derides its materiality and mechanism without recognizing how the conceptual components of technology inform art both metaphorically and concretely.[11] To complicate matters further, since the mid-1990s increasing emphasis has been placed on collaborative, interdisciplinary research at the intersections of art, science, and engineering, the outcomes of which may not easily fit into any single field but demonstrate a hybridity that merges various disciplines. Such practices may well represent not just the future of art or the future of technology, but the larger future of creativity and innovation.[12]

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Since the term "technology" emerged in the nineteenth century, it is hardly surprising that, as philosopher Patrick Maynard rightly noted in 1994, "the theme of art and technology" is usually construed "as modern industrial technology, within a very recent kind of market."[13] This recognition of the inter-relatedness of technology and economy with respect to art begs updating to account for the particular social configurations, professional practices, and personal and group behaviors that have emerged in concomitance with the proliferation of new media technologies since the mid-1990s.

The phrase "Art and Technology" is, like the term "technology," inclusive. It commonly refers to the use of any combination of relatively recent scientific or technological materials, concepts, or machines by artists in the twentieth century, especially after World War II. The concerns that Walter Benjamin expressed in his essay on art in the age of technological (*technischen*) reproducibility (*Reproduzierbarkeit*) remain

[11] See my, "Art in the Information Age: Technology and Conceptual Art," *SIGGRAPH 2001 Electronic Art and Animation Catalog*, (New York: ACM SIGGRAPH, 2001): 8-15; expanded in *Leonardo* 35:4 (August, 2002): 433-38. and Soraya Murray, "New Media Anxiety: Art History and the Problem of Modern Technology." Doctoral Dissertation, Cornell University, 2007.

[12] See my, "The History and Future of the Lab: Collaborative Research at the Intersections of Art, Science, and Technology" in Angela Plohman and Claire Butcher, eds., *The Future of the Lab. Eindhoven: Baltan Labs*, 2010, 16-29.

[13] Maynard, Patrick, Ed., *Journal of Aesthetics and Art Criticism* 55: 2 (Spring, 1997 *Special Issue: Perspectives on the Art and Technology*): 96.

of significance to many artists working with electronic media, and offered a theoretical ground for interrogating the aesthetic and political ramifications of the potentially infinite reproducibility of images and objects through mechanical means. However, as prevailing technologies have shifted from industrial production to information processing, the best new media art has tended to use technology as a symbolic and/or structural component in a critique of, or proposition about, the relationships between art, technology, and society (and the aesthetic or political consequences thereof). Here the emphasis is less on the reproduction of images or objects than on challenging traditional epistemological and ontological constructs, offering alternative modes of knowledge and being.

Benjamin recognized that the age of mechanical reproducibility held great potential for demystifying cultish hierarchies of value and countering fascist propaganda by democratizing the creation and dissemination of images. In this respect, new media art can be seen as extending a lineage of critical art practice. Indeed, the historical narratives of western art celebrate more or less radical acts of epistemic and ontological reconstruction that wrest art from extreme exclusivity, desacralize it, and reconfigure subject-object relationships. Since the early twentieth century, the intersection of art and technology has served as a vital nexus for contesting the status quo, building alternative worlds, and envisioning possible futures. Like Alan Kay, the inventor of multimedia computing who has stated that, "the best way to predict the future is to invent it," artists have created working models or proofs of concept that enable the public to experience in the present what may become a widespread phenomenon decades later. In the words of art theorist Jack Burnham, such art serves as a "psychic dress rehearsal for the future."

Art and Technology and Ideology in the 1960s

The inextricability of technology, perception, and ideology is a common theme in twentieth century thought.[14] I have argued that the phenomenon of the art and technology movement in the US, beginning in the mid-1960s, marked by an unprecedented dedication of cultural resources to large museum exhibitions on this theme, was fueled by ideological motives, including corporate and political interests as well as

[14] I have addressed the relationship of perspective as a technology with respect to ideology in my essay, "Virtual Perspective and the Artistic Vision: A Genealogy of Technology, Perception, and Power," in Michael B. Roetto, ed., *ISEA96 Proceedings of International Society for Electronic Art.* (Rotterdam: ISEA96, 1997): 57-63.

more high-minded artistic and philosophical ideals.[15] Cold War fears of nuclear apocalypse, popular backlash against the military-industrial complex during the war in Vietnam, and growing awareness of environmental pollution all contributed to growing tensions between art and technology. This concomitance of factors resulted in a desire to fuse art and technology in order to "create a more human environment," as Billy Klüver proposed. Such aims were concretized and given public expression in the striking number of major exhibitions on this theme that took place in the US between 1966 and 1971. These shows included: *9 evenings: theatre and engineering*; *Software, Information Technology: Its New Meaning for Art*; *The Machine as Seen at the End of the Mechanical Age*; *Cybernetic Serendipity*; *Art and Technology*; *Some More Beginnings*; and *Magic Theater*. They took place at such prestigious institutions as The Museum of Modern Art, New York; The San Francisco Museum of Modern Art; The Los Angeles County Museum of Art; the Institute of Contemporary Art, Boston; the Chicago Museum of Contemporary Art; the Corcoran Gallery; The Walker Art Center; the Brooklyn Museum of Art; the William Rockhill Nelson Gallery; and the Jewish Museum. Clearly, these exhibitions were neither without precursors, nor unique to the US in the post-war period. However, their scale, conception, prominence, and sheer number constitute a singular moment. Two examples: *nine evenings* (1966) and *The Machine* (1968) offer particularly useful insights into the tensions and ideological stakes involved in joining art and technology at the time.

[15] See my,"Gemini Rising, Moon in Apollo: Art and Technology in the US, 1966-71,"in *ISEA97: Proceedings of International Society for Electronic Art*. (Chicago: ISEA, 1998): 57-63.

9 evenings: Cage, Klüver, Rauschenberg, and E.A.T

A total audience of some ten thousand witnessed *9 evenings: theatre and engineering* in October 1966. Spearheaded by engineer Billy Klüver and artists Robert Rauschenberg and Robert Whitman, this series of performances consisted of work by ten artists collaborating with thirty engineers from Bell Labs. In the technical development of their work, the artists benefited from 8500 *pro bono* engineering hours (worth an estimated $150,000) provided by the engineers themselves, not by Bell Labs. [16] It was during the process of organizing *nine evenings* that Klüver and Rauschenberg initiated incorporating the foundation, Experiments in Art and Technology (E.A.T.), in order to make "materials, technology and

[16] Billy Klüver, "Theater and Engineering, an Experiment: 2. Notes by an engineer," *Art Forum* (February, 1967). Klüver's boss at Bell Labs, the eminent scientist John Pierce, permitted the engineers to work on the art projects, so long as it was not on company time.

engineering available to any contemporary artist."[17] While the event received support from a number of individual and corporate patrons, including some unauthorized "midnight requisitions" from Bell, it was funded largely by Rauschenberg and Klüver themselves, and organized by the artists and engineers who created it, independent of any formal institutional structure.

The following statement by American composer John Cage, made in the context of his participation in *9 evenings*, exemplifies a prevalent attitude held by artists toward art and technology in the 1960s.

> "I want to remove the notion of the separation between the artist and the engineer. I think that the engineer is separate from other people simply because of his very highly specialized knowledge. If the artist can become aware of the technology, and if the engineer can become aware of the fact that the show must go on, then I think that we can expect not only interesting art, but we may just very well expect an interesting change in the social order. The most important aspect of this is the position of the engineer as a possible revolutionary figure. And it may very well come [to pass] as a result of the artists and engineers collaborating. Because the artists, for years now, have been the repositories of revolutionary thought. Whereas the engineers, in their recent history, have been employees of the economic life. But in relating to the artists, they become related to a revolutionary factor."[18]

According to Cage, the artist was the progenitor of a revolutionary heritage who, through collaborations between artists and engineers, would transfer this revolutionary element to the technical servants of commerce and industry. Cage seemed to believe that this collaboration might contribute to transforming the social order. Yet, even while claiming to remove the separation between artists and engineers, the composer oversimplified the categorical distinctions between them and reduced the characteristics of each to a caricature. Cage unabashedly celebrated the artist while condescending to the engineer (the skilled worker bee in need of artistic direction) and never explained *how* this transfer of revolutionary spirit from the one to the other would come about, to say nothing of his elision of the role of artists as employees of economic life.

Cage does, however, express a common sentiment of the time: that technology had thrown the world out of balance and that revolu-

[17] *E.A.T. News* 1:1 (January 15, 1967); 2. Interestingly enough, the name was selected by their attorney, Franklin Konigsberg, when he applied for incorporation as a charitable organization on August 24, 1966. (Billy Klüver, Interview with the author, August 22, 1997.) Neither Klüver nor Rauschenberg ever liked the name, which is why they tended to use the acronym, E.A.T., and did not use the words "experiment," "art," or "technology" in the title of the event. Klüver wrote: "The name of the performances at the Armory came out of long arguments about what we were doing. The day "Art and Technology" was left behind was a day of relief for everyone." Billy Klüver, "Theater and Engineering." Because E.A.T. had not yet been granted not-for-profit status in time for the event, nine evenings was presented by Jasper Johns' non-profit organization, The Foundation for Contemporary Performance Arts.

[18] Experiments in Art and Technology, "Trailer Introducing Ten Documentary Films from 9 evenings: theatre & engineering, October 13-23, 1966." VHS. Author's transcription of Cage's oral statement.

tion was eminent. All signs pointed in that direction, with the heating up of the Cold War, made visible in the space race (spanning the Sputnik's launch (October 4, 1957) to the Apollo 11 lunar landing (July 20, 1969)), the construction of the Berlin Wall (August, 1961), the Bay of Pigs invasion (1962), and the escalating US engagement in Vietnam.[19] While the ideological conflict between capitalism and communism was the central political battleground for this crisis, technology was widely embraced in the US as the means by which the so-called American way of life would be preserved. Technology became inseparable from the growing "military-industrial complex" of which President Eisenhower had warned in his 1961 farewell address. In this way, international relations, technology, and capitalist industry constituted an allied ideological front in America. Many artists sought to counteract what they perceived as the deleterious effects of technology - such as the destructiveness of war and the pollution of the environment - by appropriating it for purportedly beneficent aesthetic purposes, which would infiltrate engineering and reform industry.[20]

Artists like Cage were not alone in holding such humanistic views on art and technology. In a 1997 interview, Klüver agreed with Cage's position in 1966, even if he considered it "tame" compared to his own much more enigmatic point of view.[21] For example, in 1968, the engineer said that, "Art and technology go well together in a world run by people who consider boredom the greatest virtue."[22] While the meaning of this statement is ambiguous, thirty years later Klüver explained that as he increasingly became involved with artists, he had begun to find science "boring." As a result of their training, he argued, engineers are "locked into a very restricted way of looking at the world," which prevents them from "using their brains to change the environment, to make a more human environment, as they should."[23] He has consistently maintained that artist-engineer collaborations might yield "technology [that] is for pleasure, variety, change, respect for individual choice and human relationships."[24]

Klüver, however, did not believe in art and technology as a unified concept because, in his opinion, each field is a separate and distinct entity, the protocols and goals of which are not translatable, much less compatible. When asked about the utopian ideal of fusing art and technology (which characterized Cage's view and much other discourse on

[19] The spirit of revolution was equally if not more salient in the civil rights and women's liberation movements, reaching a boiling point internationally in May, 1968.

[20] For more on Cage's politics see, Brandon Joseph, "Experimental Art: John Cage, Robert Rauschenberg and the Neo-Avant-Garde," doctoral dissertation, Harvard University, 1999.

[21] Billy Klüver, Interview with the author, September 19, 1997.

[22] Douglas Davis, "Art and Technology Conversations, Billy Klüver: The Engineer as a Work of Art." *Art in America* 56:1 (Jan - Feb, 1968): 42.

[23] Billy Klüver, Interview with the author, September 19, 1997.

[24] Davis, "Art and Technology Conversations": 42. Klüver maintained this position in the September 19, 1997 interview with the author.

the subject), Klüver stated in 1968, "I don't know what John's feelings are about Utopia. To me it has always sounded like a pretty dull place." For Klüver, it is the *difference* between art and technology that makes the result of their interaction worthwhile, while the idea of unifying them is a prescription for boredom. His position delimits the range of belief and skepticism that coexist at the conflicted cross-roads of art and technology.

In the program notes that Klüver wrote for *nine evenings,* he emphasized the importance of improving the status and respectability of artists in society, and of the benefits resulting from "feedback to industry from the interaction between artists and engineers."[25] In correspondence with his friend Niels Hugo Geber (Swedish scholar of violence and society), Klüver argued that "technology can be non-destructive, but only if it is created to be that way."[26] He came to believe that he "could change technology, and that art was a vehicle for that."[27] There is no better proof of his commitment to this idea than the fact that in 1968 he left the security of his prestigious job at Bell Labs in order to pursue that quest full-time as president of E.A.T.

[25] Billy Klüver, "9 evenings: theatre and engineering" (program of performance) 1966, no page numbers.

[26] Billy Klüver, Interview with the author, August 22, 1997.

[27] Billy Klüver, Telephone interview with the author, September 19, 1997.

For the November 1, 1967 issue of *E.A.T. News*, Klüver and Rauschenberg collaborated on a statement that expressed the "urgency we feel about the need for a new awareness and sense of responsibility" regarding the relationship between art and technology, and the long-range goals of E.A.T.

> MAINTAIN A CONSTRUCTIVE CLIMATE FOR THE RECOGNITION OF THE NEW TECHNOLOGY AND THE ARTS BY A CIVILIZED COLLABORATION BETWEEN GROUPS UNREALISTICALLY DEVELOPING IN ISOLATION.
>
> ELIMINATE THE SEPARATION OF THE INDIVIDUAL FROM TECHNOLOGICAL CHANGE AND EXPAND AND ENRICH TECHNOLOGY TO GIVE THE INDIVIDUAL VARIETY, PLEASURE AND AVENUES FOR EXPLORATION AND INVOLVEMENT IN CONTEMPORARY LIFE.
>
> ENCOURAGE INDUSTRIAL INITIATIVE IN GENERATING ORIGINAL FORETHOUGHT INSTEAD OF A COMPROMISE IN AFTERMATH, AND PRECIPITATE A MUTUAL AGREEMENT IN ORDER TO AVOID THE WASTE OF A CULTURAL REVOLUTION[28]

[28] Robert Rauschenberg and Billy Klüver, (untitled) *E.A.T. News* 1:3 (November 1, 1967): 5. Reproduced in all-capital letters, as it originally appeared.

Here the authors asserted that it was unrealistic for art and technology to develop separately. But wouldn't that contradict Klüver's belief in the importance of their distinctness? Moreover, wouldn't a "civilized collaboration" be a prescription for ennui - in other words, boring? Did the authors imagine that each could remain separate while collaboratively co-developing alongside one another? If so, it remains unclear how disciplinary distinctions would be maintained amidst such an arrangement or what the advantages of retaining them would be. Perhaps an "uncivilized collaboration" - such as pirate radio and television, or other guerilla art tactics - would provide more of the "variety, pleasure, and avenues for exploration..." that Rauschenberg and Klüver sought. As Jasia Reichardt, curator of the 1968 British exhibition Cybernetic Serendipity argued, "artists like Takis, Tinguely, ... Paik [and others] ... have consistently made use of technology without the help of any specific organization."[29] But even Paik, the most celebrated artist associated with art and technology, struggled financially well into the 1980s, so it remains unknown what further accomplishments he and other artists might have achieved had they received more institutional support.

[29] Jasia Reichardt, "E.A.T. and after" *Studio International* 175:900 (May 1968): 237.

Klüver and Rauschenberg's conclusion is especially striking in that it reveals a belief, or veiled threat, that if industry did not change its ways, there inevitably would be a revolution. Such a struggle would be "wasteful," an anathema to efficient engineering. In contrast to Cage's idea of the artist as a revolutionary influence on the engineer, the artist becomes the key to an efficient social transformation that could avoid the messy extravagance of revolution. Reversing the terms of the official US ideological front referred to earlier, in which technology and capitalist industry were allied against the Soviet threat, Klüver and Rauschenberg allied art and technology with the ideological concerns percolating amongst Leftist intellectuals and artists (the anti-war, civil rights, women's liberation, and environmental movements) against the repression and alienation of the military industrial complex. Ironically, the alliance of art and technology was a double-edged sword, for industry was eager to support such ventures as a means of developing a more positive corporate image, thereby co-opting the transformative potential of art and using it to reify the status quo.[30]

[30] See Hans Haacke, Hans Haacke: Unfinished Business, Brian Wallis, Ed., (New York: The New Museum of Contemporary Art, and Cambridge: MIT Press, 1986) and my "Gemini Rising...," op. cit.

Hultén, Heidegger, and The Machine

Curator Pontus Hultén's 1968 exhibition, *The Machine as Seen at the End of the Mechanical Age*, offered audiences a large, trans-historical survey of art and technology.[31] Opening at the Museum of Modern Art (MOMA) in New York, *The Machine* spanned Leonardo da Vinci's drawings of visionary flying machines (c. 1485-90) to contemporary artist-engineer collaborations that were commissioned through a competition publicized and overseen by Klüver and E.A.T.[32] Hultén had originally envisioned including approximately ten such works, however the call for proposals (advertised in the *New York Times* and *Scientific American*) resulted in some two hundred submissions from nine countries.[33] The quantity and quality of this unexpectedly enthusiastic response inspired E.A.T. to organize a parallel exhibition, *Some More Beginnings*, at the Brooklyn Museum of Art. Clearly, the interest in joining art and technology was more than a fashionable idea fabricated by curators and art institutions; individual artists and engineers were extremely interested to participate in such collaborative endeavors.

[31] The show later traveled to the Institute for the Arts, Temporary Exhibition Building at Rice University, Houston, Texas, March 26 - May 18, 1969, and opened at the San Francisco Museum of Modern Art, June 27, 1969.

[32] See *Experiments in Art and Technology, Some More Beginnings*. New York: Experiments in Art and Technology, Inc., 1968.

[33] K.G. Pontus Hultén, The Machine as Seen at the End of the Machine Age, (New York: Museum of Modern Art, 1968): 199.

By endorsing the interdependent history of art and technology with MOMA's seal of approval, Hultén, who had organized a number of important international exhibitions on kinetic art and other experimental media since the 1950s, sought, in part, to overcome popular prejudices against the use of technology in art. The curator's introductory essay in the distinctively machine-made, steel-clad catalog, offers an example of the "conflicted" (his word) views regarding the relationship between art, technology, and the human, representative of the late 1960's. On the last page he wrote:

> 'From the mid-'fifties on, ... [artists] have devoted themselves to an attempt to establish better relations with technology. Standing astonished and enchanted amid a world of machines, these artists are determined not to allow themselves to be duped by them. Their art expresses an optimistic view toward man, the creator of machines, rather than toward technology as such. They lead us to believe that in the future we may be able to achieve other, more worthy relations with machines. They have shown that while different aspects of our relations to machines may conflict, they are not necessarily contradictory. Not technology, but our misuse of it, is to blame for our present predicament'. [34]

[34] Hultén, The Machine: 13. Unless otherwise noted all other quotes are from this page of the catalog.

Hultén's optimism was buoyed by his faith in human control over technology even in the face of conflicted "relations with machines," and the "present predicament" (i.e. The Cold War, environmental pollution, and so on). Several paragraphs later, Hultén rejected the "frightening... notion that modern technology has an evolution of its own, which is uncontrollable and independent of human will." Perhaps the quickness with which the curator dismissed this menacing possibility reflected his anxiety about the real potential threat of what Harvard sociologist Langdon Winner later identified as "autonomous technology."[35]

Hultén's exhibition also included examples of early photographic and cinematic cameras, as well as photographs and films, which he claimed, "provided the basis for much of our way of seeing."[36] Thus while he recognized the significance of the proliferation and dissemination of mechanical reproduction - which was rare at that time in a museum context - Hultén did not question the nature of that impact, such as the loss of aura, availability to the masses, and political potential, that Walter Benjamin had considered earlier. Like Cage, Rauschenberg, and Klüver, but perhaps with even greater sentimentality and idealism, Hultén earnestly proposed that "the decisions that shape our society in the future must be based on the same criteria of respect and appreciation for human capacities, freedom, and responsibility that prevail in art." Hultén argued further that "we must attain a society based on other values than buying and selling," though he did not go so far as to question the complicity of art and artists in the "culture industry" and their promotion of commodity capitalism (to say nothing of technology!), as Horkheimer and Adorno contended. Nor did Hultén discuss the spectacle of art and technology manufactured by major art institutions as a consumable commodity, as Guy Debord might have insisted upon.[37] In short, Hultén's essay in no way constituted a vanguard intellectual statement.

Hultén's catalog dedication exemplifies the intimacy of his "relation with technology." For the curator dedicated the exhibition not to a family member, but to "the mechanical machine, the great creator and destroyer, at a difficult moment in its life when, for the first time, its reign is threatened by other tools." By doubling the machine into a "mechanical machine" Hultén asserted the particular mechanical quality of its embodiment in

[35] Langdon Winner, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*. Cambridge: MIT Press, 1977.

[36] Hultén, The Machine: 3.

[37] See Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," (c. 1936) in Illuminations, ed. and with an Introduction by Hannah Arendt. Trans. by Harry Zohn. (New York: Schocken Books,1969): 217-51.; Max Horkheimer and Theodore W. Adorno, "The Culture Industry: Enlightenment as Mass Deception" in *Dialectic of Enlightenment* (New York: Continuum, 1993): 120-167; and Guy Debord, Society of the Spectacle. Detroit: Editions Champ Libre, 1970.

contrast to the ephemeral disembodiment of information technology, its apparent successor as the dominant technology. He thus emphasized the material hardware of industrial manufacture, its mechanical body and flesh, so to speak. Not only was the mechanical machine anthropomorphized and eulogized as a sentient being endowed with the properties of "life" and subject to an implied demise, but it was deemed worthy of praise and honor for its contribution to the author's life and work. Ironically, Hultén claimed that "art expresses an optimistic view toward man, the creator of machines, rather than toward technology as such," but he nonetheless dedicated the catalog to technology as such, and neither to the men and women who design and use it, nor to those who supported his popularization of it in an artistic context.

Hultén's dictum that "different aspects of our relations to machines may conflict" applies well to the art discourse on technology in the 1960's. Cage believed that the revolutionary heritage of artists could be transferred to engineers with whom they worked, giving rise to changes in the social structure. Klüver and Rauschenberg maintained that collaborations between artists and engineers could avert the impending revolution by making the conditions of life more humane and engaging. Hultén held that technology itself was benign, but not the misuse of it; yet, he had faith in the human ability to control technology, and not be fooled by it.

The Machine took a position at odds with the greater anxiety towards technology expressed by Martin Heidegger, one of the most critical commentators on the relationship between art and technology. Yet even Heidegger found in art the hope for salvation from technology's dehumanizing effects. In his 1953 essay, *The Question Concerning Technology* (first published in 1954), the German philosopher wrote "Man stands so decisively in subservience to the challenging-forth (*Herausfordern*) of [technological] enframing (*Gestell)* that he ... fails to see himself as the one spoken to..." He continued, "The threat has already afflicted man in his essence."[38] John Phillips has likened Heidegger's dilemma regarding technology to Aristotle's belief that the virtue of praxis cannot be reduced to techné, both being a "form of the aporia," further noting that "we cannot make or do anything without a τέχνη, but too literal a τέχνη will destroy all we attempt to make or do."[39] Philos-

[38] Martin Heidegger, "The Question Concerning Technology," *Basic Writings*, David Farrell Krell, Ed. (New York: HarperCollins, 1977, 1993): 332-3.

[39] Phillips, 1998: 51-2.

opher Andrew Feenberg succinctly summarized Heidegger's "apocalyptic vision" that "technology is relentlessly overtaking us,"

> 'We are engaged, he claims, in the transformation of the entire world, ourselves included, into "standing reserves," raw materials to be mobilized in technical processes. Heidegger asserts that the technical restructuring of modern societies is rooted in a nihilistic will to power, a degradation of man and Being to the level of mere objects'.[40]

[40] Andrew Feenberg, *Critical Theory of Technology*. (Oxford: Oxford University Press, 1991): 7.

Philosopher Philippe Lacoue-Labarthe locates Heidegger's fear of this "irreversible" and "headlong rush of science - …of knowledge or of techné… - towards technicism" in the context of German nationalism and self-affirmation (*Selbstbehauptung*), and the university's failure - as the keeper of science and knowledge - to "radically question" the essence of technology, resulting in nihilism.[41] According to Lacoue-Labarthe, "With the failure of the project of *Selbstbehauptung* of the University and, thereby, of Germany itself, science (which supported this whole project) gives way to art, in this case to poetic thought" in Heidegger's thinking, for "it is art that is conceived in the first place as harboring within it the capacity of opening up a possibility of historical *Dasein*".[42] Lacoue-Labarthe explains that Heidegger's theorization of art's ability to surmount technological nihilism draws together relationships between art, poetry (*Dichtung*), language (*Sprache)*, and myth (*Sage*). "Only a myth … is able to allow a people to accede to its own language and thereby to situate itself as such in History," in the sense that "Homer's *word* gave Greece its gods".[43]

[41] Philippe Lacoue-Labarthe, *Heidegger, Art and Politics*, Chris Turner, Trans. Oxford: Blackwell, 1990: 54-55.

[42] Ibid: 55-56. Dasein is commonly translated as "human existence."

[43] Ibid: 56-57. Lacoue-Labarth thus situates Heidegger's aesthetics in a particularly national(istic) context, one that yearned for what Hegel, a century earlier in his "end of art thesis," described as "art's highest vocation" but dismissed as no longer possible, art having been superseded by philosophy.

Heidegger believed that technology had infected humanity at its "essence," becoming part of, and inseparable from, human consciousness. For Hultén, the human and the technological remained more highly autonomous entities with respect to consciousness, with the human remaining firmly in control. Though earlier in his essay he enumerated many of the historically and potentially destructive aspects of machines, ultimately the he believed that the artists (and curator's) "unduped" use of technology supported progressive concerns, and provided inspiration for loftier human-machine relations.

Mind the Gap: New Media, Contemporary Art, and Popular Culture

The tendency to use emerging technology in art cuts across historical periods and stylistic categories. In the twentieth century, this includes work by artists associated with movements such as kinetic art, Fluxus, pop art, performance, conceptual art, and video. The great variety of ways in which artists have used science and technology has resulted in formally disparate outcomes. Some works have used contemporary technologies, such as computer graphics, to render conventional portraits. Some have expressed recent scientific concepts by using conventional artistic materials. Others have been inspired by the potential of new media to express ideas and enable experiences in ways that would not be possible with conventional materials and techniques.

Part of the ongoing resistance to the joining of art and technology stems from a distaste of the bells and whistles that characterize many of the most banal, but also some of the most interesting, works in the field. These superficial signs of technology serve as visual markers that commonly define the "look" of new media art as a more or less discrete movement. However, a narrow conception of the genre that focuses on the materiality of gadgets occludes a richer understanding of the field's significant conceptual and perceptual contributions to the history of art.

Art and technology has been caught in a double bind. It appears to be too technological to be appreciated under conventional canons of aesthetics but it is too artistic to be appreciated according to the criteria of science or engineering. For example, Roy Ascott, the British artist most closely associated with cybernetic art in England, was not included in the landmark exhibition *Cybernetic Serendipity*, curated by Jasia Reichardt at the Institute of Contemporary Art in London because his use of cybernetics followed a primarily conceptual approach.[44] Conversely, while Ascott's 1964 essay "The Construction of Change" was quoted in the frontispiece as the anthem for Lucy Lippard's seminal *Six Years: The Dematerialization of the Art Object from 1966-1972*, Ascott's anticipation of, and contribution to, the formation of conceptual art in Britain has not received proper recognition, perhaps (and ironically) because his work was too closely allied with art and technology, even though it did not employ electronic media until 1980. The problem extends beyond the failure of electronic art to appeal to inherited codes

[44] Jasia Reichardt, interview with the author, July 30, 1998, London.

of visual signification. Indeed, much work in this field has theorized a more systemic concept of art as a dynamic process, a notion that is not easily compatible with conventional art objects and gallery spaces, much less with the conventional institutions that steward such objects and present them in their galleries.[45] At the same time, art and technology has suffered from an inability to access the latest technology and a dependence on hand-me-downs and consumer electronics. As a result, it has been unable to compete on a technological basis with the spectacularity of scientific demonstrations, mass media, or Hollywood special-effects. For an art form with futuristic aspirations, new media art (NMA) often and disappointingly appears to be more like old news.

[45] For extended discussions of this issue, see Christiane Paul, ed. *New Media Art in the White Cube and Beyond* (Berkeley: University of California Press, 2008) and Beryl Graham and Sarah Cook, *Rethinking Curating: Art after New Media* (Cambridge: MIT Press, 2011).

The lack of official recognition for art and technology as a *bona fide* movement has freed it from the constraints of academic (and journalistic) historicizing, while at the same time marginalizing it with respect to other concurrent genres in contemporary art that have gained canonical status. Although I am sympathetic to various critiques of canon-building, in the absence of other generally accepted criteria for historicizing artistic excellence, only canonization has the cultural authority to assure recognition for the field that I advocate.[46] The perennial debate about the relationship between art and technology and mainstream art has occupied artists, curators, and theorists for many decades. Central to these debates have been questions of legitimacy and self-ghettoization, the dynamics of which are often in tension with each other. In seeking legitimacy, NMA has not only tried to place its practices within the theoretical and exhibition contexts of the Museum of Contemporary Art (MCA) but has developed its own theoretical language and institutional contexts. The former attempts generally have been so fruitless and the latter so successful, that an autonomous and isolated NMA artworld emerged. It has expanded rapidly and internationally since the mid-1990s, and has all the amenities found in MCA, except, of course, the legitimacy of MCA.

[46] I have discussed this at length in my essay, "Historicizing Art and Technology: Forging a Method, Firing a Canon," in Oliver Grau, ed., *Media Art Histories.* (Cambridge: MIT Press, 2007): 43-70.

At a panel I convened at Art Basel in June 2010 with Bourriaud, Peter Weibel, and Michael Joaquin Grey, the gap between NMA and MCA became increasingly clear.[47] One obvious indication of this gap was demonstrated by the simple fact that Weibel, arguably the most powerful individual in the NMA world, and Bourriaud, arguably the most influential

[47] A video recording of the event can be found on the Art Basel's YouTube channel: https://www.youtube.com/watch?v=9p9VP1r2vc4

MCA curator and theorist, had never met before. Citing the example of photography and Impressionism, Bourriaud argued that the influences of technological media on art are most insightfully and effectively presented *indirectly*, eg. in non-technological works. As he wrote in his influential manifesto, *Relational Aesthetics*, "The most fruitful thinking … [explored] … the possibilities offered by new tools, but without representing them as *techniques*. Degas and Monet thus produced a *photographic way of thinking* that went well beyond the shots of their contemporaries."[48] On this basis, he continued, "the main effects of the computer revolution are visible today among artists who do not use computers."[49] On one hand, the metaphorical implications of technologies surely have important effects on perception, consciousness, and the construction of knowledge. But on the other hand, this position exemplifies the historical, ongoing resistance of mainstream contemporary art to recognize and accept emerging media as proper materials of art.[50]

[48] Nicolas Bourriaud, *Relational Aesthetics*. Trans. Simon Pleasance & Fronza Woods with Mathieu Copeland. (Paris: Les presses du reel, 2002): 67. First published in French, 1998.

[49] Ibid.:67.

[50] For a compilation of scholarly resources on the gap between the discourses of new media art and mainstream contemporary art, see http://hybridge.wordpress.com/

Peter Weibel astutely picked up on Bourriaud's distinction between direct/indirect influences and pointed out the hypocrisy of valuing the indirect influence of technology while ignoring the direct use of technology as an artistic medium in its own right. Weibel accurately and provocatively labeled this "media injustice." Indeed, the implicit/explicit dichotomy that Bourriaud constructs serves as a rhetorical device to elevate the former member of the pair – the lofty, theoretical ideal - at the expense of the latter – the quotidian, practical tool. That epistemological logic of binary oppositions must be challenged and its artifice and ideological aims deconstructed, in order to recognize the inseparability of artists, artworks, tools, techniques, concepts and concretions as actors in a network of signification.

On implicit influences, Bourriaud further suggests that "… art creates an awareness about production methods and human relationships produced by the technologies of its day…. [B]y shifting these, it makes them more visible, enabling us to see them right down to the consequences they have on day-to-day life." In other words, by appropriating the underlying logics of emerging technologies, taking them out of their native contexts, and embedding them in more or less traditional artistic media, their effects can be brought into greater relief. Bourriaud notes that the dizzyingly rapid development of interactive technologies in the 1990s was paralleled by artistic explorations of the "arcane mysteries of sociability and interaction."[51] Digital images, he suggests, "indirectly inspired" relational art, for just as their size and proportion may vary with the screen, which "renders virtualities material in x dimensions," so "today's artists have the same ambivalence of techniques..." and "...make up programmes... with variable outcomes, including "the possible transcoding into formats other than the one for which they have been designed."[52] Unfortunately, this proposal suggests a very limited conception of the potential of digital art and the author fails to substantiate it with concrete examples. This leaves one wondering to what extent relational artists have produced a *computationally networked way of thinking* that "goes well beyond" the new media art "of their contemporaries."

[51] Nicolas Bourriaud, *Relational Aesthetics*. Trans. Simon Pleasance & Fronza Woods with Mathieu Copeland. (Paris: Les presses du reel, 2002):70. First published in French, 1998.

[49] Ibid.:71.

In global digital culture, new media technologies are widely available and accessible to a growing proportion of the population. In 2014, over two billion people around the world participated in social media, producing and sharing their own texts, images, sound recordings, videos, and GPS traces. In many ways early NMA works that enabled remote collaboration and interaction, such as Ascott's *La Plissure du Texte* (1983), can be seen as modeling social values and practices that have emerged in tandem with the advent of Web 2.0 and participatory culture. Now a YouTube video, like *Daft Hands*, can delight and amaze nearly 50 million viewers (March 2011), spawning its own subculture of celebrities, masterpieces, and remixers. In this context, one might ask what role the professional artist can play.

Like their precursors in the longer history of art and technology, specialized artistic practices that deploy the materials and techniques of new media pursue critical and metaphorical approaches to the social implications of the current technological milieu. These approaches contest existing forms of knowledge and construct new forms of understanding in ways that are substantively different than the approaches of other disciplines. Like *9 evenings*, the memes they transmit will ripple through culture slowly and profoundly. Due to the complex, and often paradoxical layering of aesthetic concepts and materials, such approaches are difficult for non-specialists to grasp. As such, they are unlikely to be popular on YouTube.

YouTube popularity, however, is no more valid as a criterion for judging such artistic research than it would be for judging scientific research. *Daft Hands* is an iconic manifestation of participatory culture and is highly successful by the criteria of that culture, i.e. YouTube popularity. For all of its appealing cleverness, virtuosity, and style, *Daft Hands* does not, as *La Plissure du Texte* did, create a working model of a possible future world, much less accurately anticipate some key features of that world (i.e. the world of participatory culture in which *Daft Hands* circulates). To use Bourriaud's aesthetic criteria, *Daft Hands*, does not, as *La Plissure du Texte* did, imbue "symbolic value" to "the 'world' it suggests to us and of the image of human relations reflected by it." By deploying a metacritical method that responds to cultural exigencies with a visionary propensity to create working models of alternative futures, the best new media art thus distinguishes itself from the use of similar materials and techniques in pop culture.

McLuhan claimed that "the serious artist is the only person able to encounter technology with impunity." Indeed, technological media provides precisely the tools artists need to reflect on the profound ways in which those same tools are deeply embedded in modes of knowledge production, perception, and interaction, and is thus inextricable from corresponding epistemological and ontological transformations. Such a metacritical approach may offer the most advantageous vantage from which to comment on and participate in the social transformations taking place in digital culture today, in order to, as Bourriaud implores, "*inhabit the world in a better way.*"

Collaboration at the Intersections of Art and Technology

The collaborations involving E.A.T. and Bell Labs exemplify the substantial history of research at the intersection of art and technology. Coinciding with the recent obsession with interdisciplinarity in academia, the proliferation of new media technologies and cultural practices (including new media art) that emerged in the 1990s has stimulated renewed interest in collaboration at the intersections of art, science, and technology (AST).

Interdisciplinary research is, in general, plagued with challenges regarding evaluative criteria. The relevance or success of an extraordinary AST project often cannot be gauged at the moment of its creation. Those who lack expertise in the key fields contributing to it will have difficulty evaluating it in either artistic or scientific terms, much less in framing its potential historical significance. If outcomes lie between or beyond the limits of any single discipline, how can their contribution to scholarship be ascertained and how can the roles of the individual researchers be judged within their respective field?

Although several patents were generated as a result of the innovations resulting from *9 evenings*, Klüver downplayed the significance of the intellectual property, which might otherwise signify the originality and relevance of applied scientific research. Bell was regularly generating patents, so that was nothing extraordinary. Klüver was more interested in the more subtle and profound impact of joining artists and technologists. Although he would not have used these words, he may well have understood that art infects culture with memes that are transformational on levels that are more metaphorical than practical. Like a pebble that alters the shape of a snowball as its circumference grows, artistic memes operate over relatively slow time frames, but can deeply impact society because they operate close to, and affect the core of, human values. Related ideas were circulating at the time, as in John Latham's concept of "time base." With this in mind, Latham and Barbara Steveni founded the Artist Placement Group (APG) in 1966 (the same year as *9 evenings*) in order to expand the role of artists and artistic processes of discovery beyond the traditional confines of art, penetrating into industry, government, and other organizational structures.

Compared with the generation of patents or publications, the impacts of such artistic memes are much more difficult to track and cannot be easily quantified. The reception of *9 evenings* was confused and conflicted. Yet, despite being panned by critics, the event succeeded in popularizing and capturing the public's imagination about the idea of artist-engineer collaborations. E.A.T. and *9 evenings* have gained legendary stature, inspiring subsequent AST research for over four decades.

As Niels Bohr has ironically noted, "prediction is difficult, especially about the future." The current relevance of E.A.T. demonstrates how difficult it can be to recognize important innovations even when they are staring you in the face. This insight is particularly relevant with respect to cutting-edge research that heralds new forms of practice, whose outcomes do not easily fit established norms and evade conventional evaluative rubrics. Indeed, throughout history, the present has demonstrated a remarkable inability to recognize what its most important contributions to the future will be. With this observation in mind, one must take into account that the outcomes and modes of operation of AST, although seemingly banal today, may be the breakthroughs of tomorrow.

In the 1960's, Klüver hoped that the joining of art and technology would "create a more human environment." Today, the idealism that pervades collaborative AST research focuses more on generating hybrid forms of creativity that transcend the limits of any single discipline, push conventional structures of knowledge, and yield breakthrough innovation. Evidence suggests that this is not just empty rhetoric. Harvard Business School professor Lee Fleming has noted that, "a creative team … [comprised] of very similar disciplines … will be unlikely to achieve a breakthrough," whereas a more diverse one (e.g. joining art, science, and engineering) "is more likely to achieve breakthroughs," though with a greater proportion of insignificant outcomes.[53]

[53] Lee Fleming, "Perfecting Cross-Pollination" *Harvard Business Review* (Sep 2004).

If AST collaborations seek to generate breakthroughs, they must take extraordinary risks and be willing to fail most of the time. Moreover, new methods for ascertaining the value of the outcomes of such research – and for recognizing the importance of process as an outcome in and of itself – must be developed.

As Florian Schneider has observed, "Collaborations are the black holes of knowledge regimes. They willingly produce nothingness, opulence, and ill-behaviour." He claims that, "it is their very vacuity that is their strength…. the setting in motion of a chain of unforeseen accesses."[54] It is into these vacuous black holes that AST research must boldly plunge, enabling the unforeseen to emerge in its opulent nothingness. Participants must be willing to take risks, to cross boundaries, and to collaborate in unconventional ways that involve 'putting themselves out on a limb,' as the artists and engineers did when producing *9 evenings*. They must be ready to deal with the challenges of translating across disci-

[54] Florian Schneider, "Collaboration. Seven Notes on New Ways of Learning and Working Together," 2007. http://www.kein.org/node/89 Cited 20 September, 2010.

plines that employ very different descriptive languages, methodologies, and goals. Inevitably misunderstandings will arise, tensions will build, and egos will be bruised. Such conflicts should be embraced as a crucial and creative catalyst for innovation. Werner Heisenberg remarked that, 'in the history of human thinking the most fruitful developments frequently take place at those points where two different lines of thought meet.' But it is frequently at the points of friction between two different lines of thought that the most innovative breakthroughs occur. Creative frictions at the intersections of art and technology demand that transdisciplinary teams forge hybrid forms of knowledge production that generate insights and results that could not have been achieved by using the methods and techniques of any single discipline.

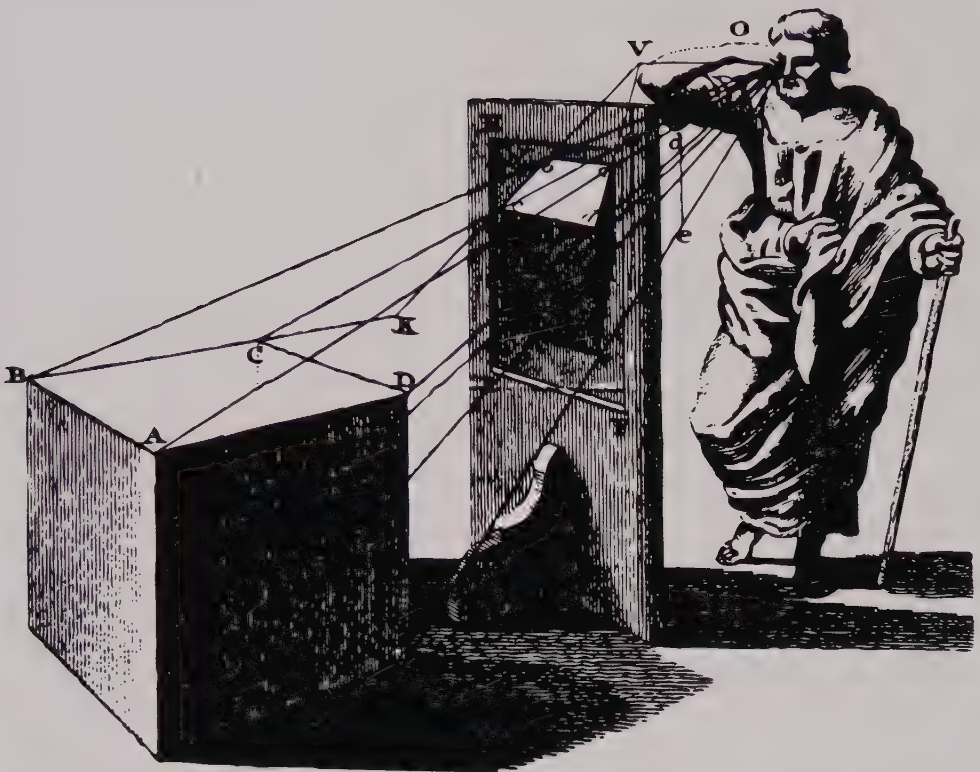
On a philosophical level, if the fruits of AST research are not strictly art, science, or engineering, then one must wonder about the epistemological and ontological status of these hybrid forms: what exactly are they? What new knowledge do they produce or enable? What is their function in the world? On a practical level, the future sustainability of such research depends on answering these questions, because the careers of artists and scholars, whose work fuses art and technology, will be prematurely curtailed if their contributions are not recognized and rewarded. Those working at the intersections of AST must develop compelling rationales for the importance of their work as an engine for innovation – innovation not just as an immediately marketable commodity but as constituting more subtle and perhaps more insidious and profound shifts in the conception and construction of knowledge and society.

Perception of the Future and the Future of Perception [1]

Heinz von Foerster

"The definition of a problem and the action taken to solve it largely depend on the view which the individuals or groups that discovered the problem have of the system to which it refers. A problem may thus find itself defined as a badly interpreted output, or as a faulty output of a faulty output device, or as a faulty output due to a malfunction in an otherwise faultless system, or as a correct but undesired output from a faultless and thus undesirable system. All definitions but the last suggest corrective action; only the last definition suggests change, and so presents an unsolvable problem to anyone opposed to change."

— Herbert Brün, 1971.[2]



Truisms have the disadvantage that by dulling the senses they obscure the truth. Almost nobody will become alarmed when told that in times of continuity the future equals the past. Only a few will become aware that from this follows that in times of socio-cultural change the future will *not* be like the past. Moreover, with a future not clearly perceived, we do not know how to act with only one certainty left: if we don't act ourselves, we shall be acted upon. Thus, if we wish to be subjects, rather than objects, what we see now, that is, our perception, must be foresight rather than hindsight.

[1] This article is an adaptation of an address given on March 29, 1971, at the opening of the Twenty-fourth Annual Conference on World Affairs at the University of Colorado, Boulder, Colorado, U.S.A. reprinted from Von Foerster, Heinz. "Perception of the future and the future of perception." *Instructional Science* 1, no. 1 (1972): 31-43.
[2] Brün, H. 'Technology and the Composer,' in Von Foerster, H., ed., *Interpersonal Relational Networks*. (Cuernavaca: Centro Intercultural de Documentacion, 1971) 1–10.

Epidemic

My colleagues and I are, at present, researching the mysteries of cognition and perception. When, from time to time, we look through the windows of our laboratory into the affairs of this world, we become more and more distressed by what we now observe. The world appears to be in the grip of a fast-spreading disease which, by now, has assumed almost global dimensions. In the individual the symptoms of the disorder manifest themselves by a progressive corruption of his faculty to perceive, with corrupted language being the pathogene, that is, the agent that makes the disease so highly contagious. Worse, in progressive stages of this disorder, the afflicted become numb, they become less and less aware of their affliction.

This state of affairs makes it clear why I am concerned about perception when contemplating the future, for:

if we can't perceive,

we can't perceive of the future

and thus, we don't know how to act now.

I venture to say that one may agree with the conclusion. If one looks around, the world appears like an anthill where its inhabitants have lost all sense of direction. They run aimlessly about, chop each other to pieces, foul their nest, attack their young, spend tremendous energies in building artifices that are either abandoned when completed, or when maintained, cause more disruption than was visible before, and so on. Thus, the conclusions seem to match the facts. Are the premises acceptable? Where does perception come in?

Before we proceed, let me first remove some semantic traps, for—as I said before—corrupt language is the pathogene of the disease. Some simple perversions may come at once to mind, as when "incursion" is used for "invasion," "protective reaction" for "aggression," "food denial" for "poisoning men, beasts, and plants," and others. Fortunately, we have developed some immunity against such insults, having been nourished with syntactic monstrosities as "X is better" without ever saying "than what." There are, however, many more profound semantic confusions, and it is these to which I want to draw your attention now.

There are three pairs of concepts in which one member of these pairs is generally substituted for the other so as to reduce the richness of our conceptions. It has become a matter of fact to confuse process with substance, relations with predicates, and quality with quantity. Let me illustrate this with a few examples out of a potentially very large catalogue, and let me at the same time show you the paralytic behavior that is caused by this conceptual dysfunction.

Process/Substance

The primordial and most proprietary processes in any man and, in fact, in any organism, namely "information" and "knowledge," are now persistently taken as commodities, that is as substance. Information is, of course, the process by which knowledge is acquired, and knowledge is the processes that integrate past and present experiences to form new activities, either as nervous activity internally perceived as thought and will, or externally perceivable as speech and movement.[3] [4] [5] [6]

Neither of these processes can be "passed on" as we are told in phrases like, "Universities are depositories of Knowledge which are passed on from generation to generation," etc., for *your* nervous activity is just *your* nervous activity and, alas, not *mine*.

No wonder that an educational system that confuses the process of creating new processes with the dispensing of goods called "knowledge" may cause some disappointment in the hypothetical receivers, for the goods are just not coming: there are no goods.

Historically, I believe, the confusion by which knowledge is taken as substance comes from a witty broadsheet printed in Nuremberg in the Sixteenth Century. It shows a seated student with a hole on top of his head into which a funnel is inserted. Next to him stands the teacher who pours into this funnel a bucket full of "knowledge," that is, letters of the alphabet, numbers and simple equations. It seems to me that what the wheel did for mankind, the Nuremberg Funnel did for education: we can now roll faster down the hill.

Is there a remedy? Of course, there is one! We only have to perceive lectures, books, slides and films, etc., not as *information* but

[3] Maturana, H. R. 'Biology of Cognition' *BCL Report No. 9.0,* Biological Laboratory, Department of Electrical Engineering, University of Illinois, Urbana (1970) 93.
[4] Maturana, H. R. 'Neurophysiology of Cognition,' in Garvin, P., ed., *Cognition, A Multiple View* (New York: Spartan Books, 1971) 3–23.
[5] Von Foerster, H. "What is Memory that It May Have Hindsight and Foresight as well?", in Bogoch, S., ed., *The Future of the Brain Sciences*, (New York: Plenum Press, 1969) 19–64.
[6] Von Foerster, H. (1971). "Thoughts and Notes on Cognition," in Garvin, P., ed., *Cognition, A Multiple View*, (New York: Spartan Books, 1971) 25–48.

as *vehicles* for potential information. Then we shall see that in giving lectures, writing books, showing slides and films, etc., we have not solved a problem, we just created one, namely, to find out in which context can these things be seen so that they create in their perceivers new insights, thoughts, and actions.

Relation/Predicate

Confusing relations with predicates has become a political pastime. In the proposition "spinach is green," "green" is a predicate; in "spinach is good," "good" is a relation between the chemistry of spinach and the observer who tastes it. He may refer to his relation with spinach as "good." Our mothers, who are the first politicians we encounter, make use of the semantic ambiguity of the syntactic operator "is" by telling us "spinach *is* good"' as if they were to say "spinach is *green*."

When we grow older we are flooded with this kind of semantic distortion that could be hilarious if it were not so far reaching. Aristophanes could have written a comedy in which the wisest men of a land set out to accomplish a job that, in principle, cannot be done. They wish to establish, once and for all, all the properties that define an obscene object or act. Of course, "obscenity" is not a property residing within things, but a subject-object relationship, for if we show Mr. X a painting and he calls it obscene, we know a lot about Mr. X but very little about the painting. Thus, when our lawmakers will finally come up with their imaginary list, we shall know a lot about them, but their laws will be dangerous nonsense.

"Order" is another concept that we are commanded to see in things rather than in our perception of things. Of the two sequences A and B,

A: 1,2,3,4,5,6,7,8,9

B: 8,5,4,9,1,7,6,3,2

Sequence A is seen to be ordered while B appears to be in a mess, until we are told that B has the same beautiful order as A, for B is in alphabetical order (eight, five, four, . . .). "Everything has order once it is understood" says one of my friends, a neurophysiologist, who can see order in what appears to me at first the most impossible scramble of cells. My insistence here to recognize "order" as a subject-object relation and not to confuse it with a property of things may seem too pedantic. However, when it comes to the issue "law and order" this confusion may have lethal consequences. "Law and order" is no issue, it is a desire common to all; the issue is "which laws and what order," or, in other words, the issue is "justice and freedom."

Castration

One may dismiss these confusions as something that can easily be corrected. One may argue that what I just did was doing that. However, I fear this is not so; the roots are deeper than we think. We seem to be brought up in a world seen through descriptions by others rather than through our own perceptions. This has the consequence that instead of using language as a tool with which to express thoughts and experience, we accept language as a tool that determines our thoughts and experience.

It is, of course, very difficult to prove this point, for nothing less is required than to go inside the head and to exhibit the semantic structure that reflects our mode of perception and thinking. However, there are now new and fascinating experiments from which these semantic structures can be inferred. Let me describe one that demonstrates my point most dramatically.

The method proposed by George Miller[7] consists of asking independently several subjects to classify on the basis of similarity of meaning a number of words printed on cards (Figure 1). The subject can form as many classes as he wants, and any number of items can be placed in each class. The data so collected can be represented by a "tree" such that the branchpoints further away from the "root"' indicate stronger agreement among the subjects and hence suggest a measure of similarity in the meaning of the words for this particular group of subjects.

[7] Miller, G. A. "Psycholinguistic Approaches to the Study of Communication," in Arm, D. L., ed., *Journeys in Science*, (Albuquerque University: New Mexico, 1967) 22–73.

AGAIN	AIR	APPLE	BRING	CHEESE	COLD
COME	DARK	DOCTOR	EAT	FIND	FOOT
HARD	HOUSE	INVITE	JUMP	LIVE	MILK
NEEDLE	NOW	QUICKLY	SADLY	SAND	SEND
SLEEP	SLOWLY	SOFT	SUFFER	SUGAR	SWEET
TABLE	TAKE	VERY	WATER	WEEP	WHITE

Figure 1. Example of 36 words printed on cards to be classified according to similarity in meaning.

Fig. 2 shows the result of such a "cluster analysis" of the 36 words of Figure 1 by 20 adult subjects ("root" on the left). Clearly, adults classify according to syntactic categories, putting nouns in one class (bottom tree), adjectives in another (next to bottom tree), then verbs, and finally those little words one does not know how to deal with.

The difference is impressive when the adults' results are compared with the richness of perception and imagery of children in the third and fourth grade when given the same task (Figure 3). Miller reflects upon these delightful results:

> "Children tend to put together words that might be used in talking about the same thing—which cuts right across the tidy syntactic boundaries so important to adults. Thus all twenty of the children agree in putting the verb 'eat' with the noun 'apple'; for many of them 'air' is 'cold'; the 'foot' is used to 'jump'—You 'live' in a 'house'; 'sugar' is 'sweet', and the cluster of 'doctor,' 'needle,' 'suffer,' 'weep' and 'sadly' is a small vignette in itself."

What is wrong with our education that castrates our power over language? Of the many factors that may be responsible I shall name only one that has a profound influence on our way of thinking, namely, the misapplication of the "scientific method."

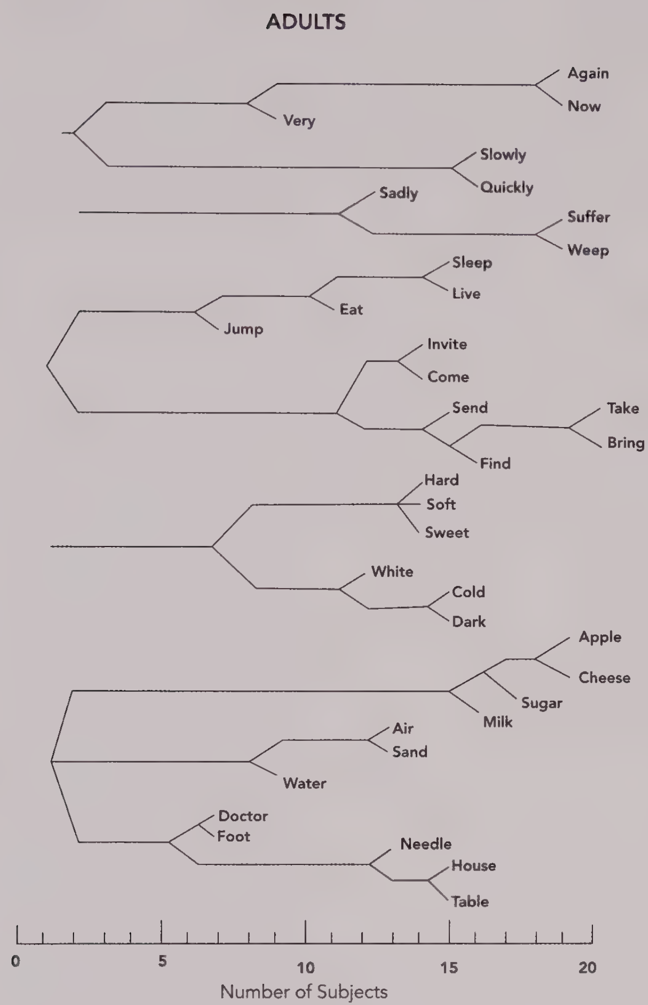


Figure 2. Cluster analysis of the 36 words of Fig. 1 classified by 20 adult subjects. Note that syntactic categories are faithfully respected, while semantic relations are almost completely ignored.

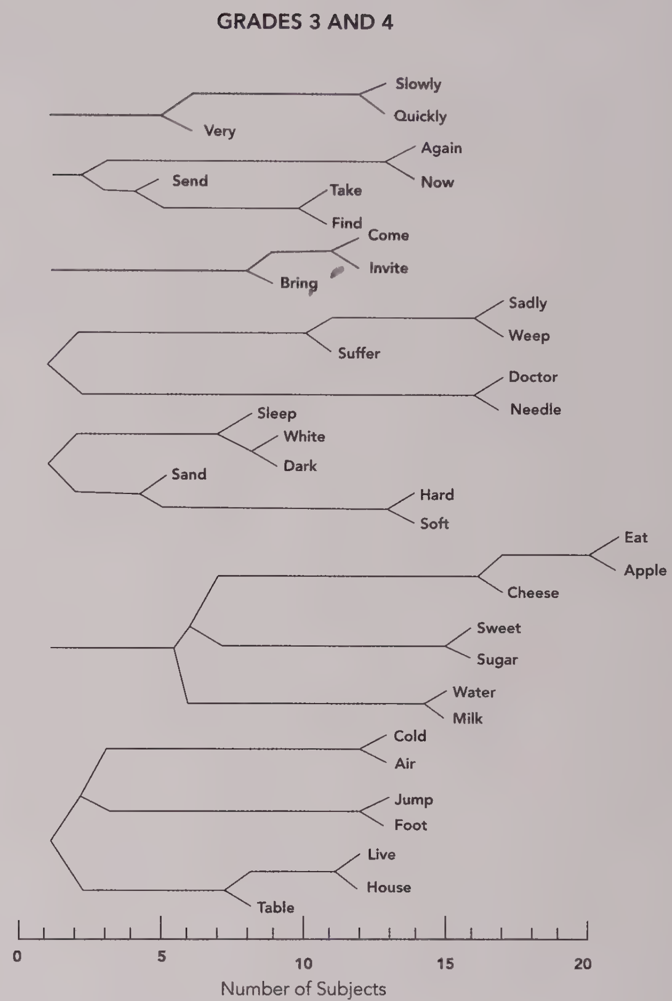


Figure 3. The sample 36 words of Figs. 1 and 2 classified by children in the third and fourth grade. Note the emergence of meaningful cognitive units, while syntactic categories are almost completely ignored.

Scientific Method

The scientific method rests on two fundamental pillars:

(i) Rules observed in the past shall apply to the future. This is usually referred to as the principle of conservation of rules, and I have no doubt that you are all familiar with it. The other pillar, however, stands in the shadow of the first and thus is not so clearly visible:

(ii) Almost everything in the universe shall be irrelevant. This is usually referred to as the principle of the necessary and sufficient cause, and what it demands is at once apparent when one realizes that "relevance" is a triadic relation that relates a set of propositions (*P1*, *P2*, ...) to another set of propositions (*Q1*, *Q2*, ...) in the mind (*M*) of one who wishes to establish this relation. If *P* are the causes that are to explain the perceived effects *Q*, then the principle of necessary and sufficient cause forces us to reduce our perception of effects further and further until we have hit upon the necessary and sufficient cause that produces the desired effect: everything else in the universe shall be irrelevant.

It is easy to show that resting one's cognitive functions upon these two pillars is counter-productive in contemplating any evolutionary process, be it the growing up of an individual, or a society in transition. In fact, this was already known by Aristotle who distinguished two kinds of cause, one the "efficient cause," the other the "final cause," which provide us with two distinct explanatory frameworks for either inanimate matter, or else living organisms, the distinction being that the efficient cause *precedes* its effect while the final cause *succeeds* its effect. When striking with a match the treated surface of a matchbook, the striking is the (efficient) cause for tile match to ignite. However, the cause for my striking the match is my wish to have it ignited (final cause).

Perhaps, with this distinction, my introductory remarks may appear much clearer. Of course, I had in mind the final cause when I said that if we can perceive of the future (the match being ignited), we know how to act now (strike!). This leads me immediately to draw a conclusion, namely: at any moment we are free to act toward the future we desire. In other words, the future will be as we wish and perceive it to be. This may come as a shock only to those who let their thinking be governed by the principle that demands that only the rules observed in the past shall apply to the future. For those the concept of "change" is inconceivable, for change is the process that obliterates the rules of the past.

Quality/Quantity

In order to protect society from the dangerous consequences of change, not only a whole branch of business has emerged, but also the Government has established several offices that busy themselves in predicting the future by applying the rules of the past. These are the Futurists. Their job is to confuse quality with quantity, and their products are "'future scenarios" in which the qualities remain the same, only the quantities change: more cars, wider highways, faster planes, bigger bombs, etc. While these "future scenarios" are meaningless in a changing world, they have become a lucrative business for entrepreneurs who sell them to corporations that profit from designing for obsolescence.

With the diagnosis of the deficiency to perceive qualitative change, that is, a change of our subject-object and subject-subject relationships, we are very close to the root of the epidemic that I mentioned in my opening remarks. An example in neurophysiology may help to comprehend the deficiency that now occurs on the cognitive level.

Dysgnosis

The visual receptors in the retina, the cones and the rods, operate optimally only under certain conditions of illumination. Beyond or below this condition we suffer a loss in acuity or in color discrimination. However, in the vertebrate eye the retina almost always operates under these optimal conditions, because of the iris that contracts or dilates so as to admit under changing conditions of brightness the same amount of light to the receptors. Hence, the scenario "seen" by the optic nerve has always the same illumination independent of whether we are in bright sunshine or in a shaded room. How, then, do we know whether it is bright or shady?

The information about this datum resides in the regulator that compares the activity in the optic nerve with the desired standard and causes the iris to contract when the activity is too high, and to dilate when it is too small. Thus, the information of brightness does not come from inspecting the scenario—it appears always to be of similar brightness—it comes from an inspection of the regulator that suppresses the perception of change.

There are subjects who have difficulties in assessing the state of their regulator, and thus they are weak in discriminating different levels of brightness. They are called "dysphotic." They are the opposite of photographers, who may be called "photic," for they have a keen sense of brightness discrimination. There are subjects who have difficulties in assessing the regulators that maintain their identity in a changing world. I shall call individuals suffering from this disorder "dysgnostic," for they have no way of knowing themselves. Since this disorder has assumed extraordinary dimensions, it has indeed been recognized at the highest national level.

As you all know, it has been observed that the majority of the American people cannot speak. This is interpreted by saying that they are "silent"; I say they are *mute*. However, as you all know very well, there is nothing, wrong with the vocal tract of those who are mute: the cause of their muteness is deafness. Hence, the so-called "silent majority" is *de facto* a "deaf majority."

However, the most distressing thing in this observation is that there is again nothing wrong with their auditory system; they could hear if they wanted to: but they don't want to. Their deafness is voluntary, and in others it is their blindness.

At this point proof will be required for these outrageous propositions. *TIME Magazine* (1970)[8] provides it for me in its study of Middle America.

[8] TIME Magazine. *"The Middle Americans"*, (January 5, 1970).

There is the wife of a Glencoe, Illinois lawyer, who worries about the America in which her four children are growing up: "I want my children to live and grow up in an America as I knew it," [note the principle of conservation of rule where the future equals the past] "where we were proud to be citizens of this country. I'm damned sick and tired of listening to all this nonsense about how awful America is." [Note voluntary deafness.]

Another example is a newspaper librarian in Pittsfield, Massachusetts, who is angered by student unrest: "Every time I see protestors, I say, 'Look at those creeps.'" [Note reduction of visual acuity.] "But then my 12-year old son says, 'They're not creeps. They have a perfect right to do what they want'" [Note the un-adult-erated perceptual faculty in the young.]

The tragedy in these examples is that the victims of "dysgnosis" not only do not know that they don't see, hear, or feel, they also do not want to.

How can we rectify this situation?

Trivialization

I have listed so far several instances of perceptual disorders that block our vision of the future. These symptoms collectively constitute the syndrome of our epidemic disease. It would be the sign of a poor physician if he were to go about relieving the patient of these symptoms one by one, for the elimination of one may aggravate another. Is there a single common denominator that would identify the root of the entire syndrome?

To this end, let me introduce two concepts, they are the concepts of the "trivial" and the "non-trivial" machine. The term "machine" in this context refers to well-defined functional properties of an abstract entity rather than to an assembly of cogwheels, buttons and levers, although such assemblies may represent embodiments of these abstract functional entities.

A trivial machine is characterized by a one-to-one relationship between its "input" (stimulus, cause) and its "output" (response, effect). This invariable relationship is "the machine." Since this relationship is determined once and for all, this is a deterministic system; and since an output once observed for a given input will be the same for the same input given later, this is also a predictable system.

Non-trivial machines, however, are quite different creatures. Their input-output relationship is not invariant, but is determined by the machine's previous output; its previous steps determine its present reactions. While these machines are again deterministic systems, for all practical reasons they are unpredictable: an output once observed for a given input will most likely be not the same for the same input given later.

In order to grasp the profound difference between these two kinds of machines it may be helpful to envision "internal states" in these machines. While in the trivial machine only one internal state participates always in its internal operation, in the non-trivial machine it is the shift from one internal state to another that makes it so elusive.

One may interpret this distinction as the Twentieth Century version of Aristotle's distinction of explanatory frameworks for inanimate matter and living organisms.

All machines we construct and buy are, hopefully, trivial machines. A toaster should toast, a washing machine wash, a motorcar should predictably respond to its driver's operations. In fact, all our efforts go into one direction, to create trivial machines or, if we encounter non-trivial machines, to convert them into trivial machines. The discovery of agriculture is the discovery that some aspects of Nature can be trivialized: If I till today, I shall have bread tomorrow.

Granted, that in some instances we may be not completely successful in producing ideally trivial machines. For example, one morning turning the starter key to our car, the beast does not start. Apparently it changed its internal state, obscure to us, as a consequence of previous outputs (it may have exhausted its gasoline supply) and revealed for a moment its true nature of being a nontrivial machine. But this is, of course, outrageous and this state of affairs should be remedied at once.

While our pre-occupation with the trivialization of our environment may be in one domain useful and constructive, in another domain it is useless and destructive. Trivialization is a dangerous panacea when man applies it to himself.

Consider, for instance, the way our system of education is set up. The student enters school as an unpredictable "non-trivial machine." We don't know what answer he will give to a question. However, should he succeed in this system the answers he gives to our questions must be known. They are the "right" answers:

Q: "When was Napoleon born?"

A: "1769"

Right!

Student = Student

but

Q: "When was Napoleon born?"

A: "Seven years before the Declaration of Independence."

Wrong!

Student = Non-student

Tests are devices to establish a measure of trivialization. A perfect score in a test is indicative of perfect trivialization: the student is completely predictable and thus can be admitted into society. He will cause neither any surprises nor any trouble.

Future

I shall call a question to which the answer is known an "illegitimate question." Wouldn't it be fascinating to contemplate an educational system that would ask of its students to answer "legitimate questions" that is questions to which the answers are unknown (H. Brün in a personal communication). Would it not be even more fascinating to conceive of a society that would establish such an educational system? The necessary condition for such an utopia is that its members perceive one another as autonomous, non-trivial beings. Such a society shall make, I predict, some of the most astounding discoveries. Just for the record, I shall list the following three:

1. Education is neither a right nor a privilege: it is a necessity.
2. Education is learning to ask legitimate questions.

A society who has made these two discoveries will ultimately be able to discover the third and most utopian one:

3. "A is better off when B is better off."

From where we stand now, anyone who seriously makes just one of those three propositions is bound to get into trouble. Maybe you remember the story Ivan Karamazov makes up in order to intellectually needle his younger brother Alyosha. The story is that of the Great Inquisitor. As you recall, the Great Inquisitor walks on a very pleasant afternoon through his town, I believe it is Salamanca; he is in good spirits. In the morning he has burned at the stakes about a hundred and twenty heretics, he has done a good job, everything is fine. Suddenly there is a crowd of people in front of him, he moves closer to see what's going on, and he sees a stranger who is putting his hand onto a lame person, and that lame one can walk. Then a blind girl is brought before him, the stranger is putting his hand on her eyes, and she can see. The Great Inquisitor knows immediately who He is, and he says to his henchmen: "Arrest this man." They jump and arrest this man and put Him into jail. In the night the Great Inquisitor visits the stranger in his cell and he says: "Look, I know who You are, troublemaker. It took us one thousand and five hundred years to straighten out the troubles you have sown. You know very well that people can't make decisions by themselves. You know very well people can't be free. We have to make their decisions. We tell them who they are to be. You know that very well. Therefore, I shall burn You at the stakes tomorrow." The stranger stands up, embraces the Great Inquisitor and kisses him. The Great Inquisitor walks out, but, as he leaves the cell, he does not close the door, and the stranger disappears in the darkness of the night.

Let us remember this story when we meet those troublemakers, and let us keep the door open for them. We shall recognize them by an act of creation:

"Let there be vision: and there was light."

Contributors

Editors

Mark-David Hosale (www.mdhosale.com) is a computational artist and composer who has given lectures and taught internationally at institutions in Denmark, The Netherlands, Norway, Canada, and the United States. He is an Associate Professor in Computational Arts in the School of the Arts, Media, Performance, and Design, Toronto, Ontario, Canada. His solo and collaborative work has been exhibited internationally at such venues as the SIGGRAPH Art Gallery (2005), International Symposium on Electronic Art (ISEA2006), BlikOpener Festival, Delft, The Netherlands (2010), the Dutch Electronic Art Festival (DEAF2012), Biennale of Sidney (2012), Toronto's Nuit Blanche (2012), Art Souterrain, Montréal (2013), and a Collateral event at the Venice Biennale (2015), among others. Mark-David's research and work explores the boundaries between the virtual and the physical world. His work as an artist and composer is an interdisciplinary practice that is often built on collaborations with architects, scientists, and other artists in the field of computational arts. His research activities support his work and are concerned with the development of custom solutions (electronics hardware and software), primarily for the development of technology-based interactive art works, using open source and open platform resources in their development.

Sana Murrani is an urban theorist and an experimental architect. She currently holds the position of Associate Head of School for Graduate Affairs for the School of Art, Design and Architecture at the University of Plymouth, UK. This is in addition to her role as the Stream Leader for History and Theory of Architecture and Critical Context. Sana's main research interest is in the field of critical urban theory with a particular focus on the transient conditions of marginality and displacement. Her work focuses on linking contemporary spatial and urban philosophy and current critical theories of social practice in order to reveal the conditions of the marginalised, the contested and the peripheral in any inhabited situation/urban context. She has published in peer-reviewed journals and participated in international conferences and workshops. Sana is currently a reviewer for Leonardo Reviews: The International Society for the Arts, Sciences, and Technology and is a guest reviewer for Routledge Architecture section. Sana recently became a member of the ESRC Global Challenge Research Fund Peer Review College.

Alberto de Campo (http://medienhaus.udk-berlin.de/pages/Dr._Alberto_De_Campo) Prof. Alberto de Campo is a composer and performer, and teaches Generative Art/Computational Art. After studying classical composition, jazz guitar and electronic/computer music in Austria and the U.S., he has worked as Research Director at CREATE, UC Santa Barbara, and taught computer music and sound art at Music University Graz and Media Arts Academy Cologne. He was the Edgard Varese guest professor for Electronic Music at Technical University Berlin in 2005, and was lead researcher in the SonEnvir project (2005-2007), an interdisciplinary research venture on sonifying scientific data from different domains. In 2007, he became Professor for Music Informatics at Music University Duesseldorf, and since 2009, he is Professor for Generative Art/ Computational Art at the University for the Arts Berlin. He explores a wide range of topics in collaborations with other artists and students: Code-based network music performance, biologically informed/inspired art such as the project Varia Zoosystematica, hybrid audiovisual performance instruments and interactive systems, and improvisation strategies in different contexts.

Authors

Sofian Audry holds a Ph. D. in Humanities from Concordia University, Montréal, Canada. He is Assistant Professor in the New Media Department, University of Maine, Orono, USA. Audry creates computational artistic works through different forms such as robotics, electronics intervention, interactive installations and net art. He holds a bachelor's degree in Computer Sciences and Mathematics, a M. Sc. in Computer Science from the University of Montreal (machine learning and language modeling), an M.A. in Communications from UQAM (interactive media), and was a Postdoctoral Fellow at the Massachusetts Institute of Technology in 2017. His work and research have been presented and published in Canada, Europe, Asia, and Africa in many festivals and exhibitions.

Philip Beesley, MRAIC OAA RCA, visual artist, architect, Professor at the University of Waterloo and European Graduate School. He serves as the Director for the Living Architecture Systems Group and Riverside Architectural Press. His research focuses on responsive and distributed architectural environments and interactive systems, flexible lightweight structures integrating kinetic functions, microprocessing, sensor and actuator systems, with particular focus on digital fabrication methods. Beesley has authored and edited sixteen books and proceedings, and has appeared on the cover of Artificial Life (MIT), LEONARDO and AD journals. Features include national CBC news, Vogue, WIRED, and a series of TED talks. His work was selected to represent Canada at the 2010 Venice Biennale for Architecture, and has received distinctions including the Prix de Rome, VIDA 11.0, FEIDAD, Azure AZ, and Architizer A+.

Dr. Laura Beloff is an internationally acclaimed artist and a researcher. Research interests include practice-based investigations into a combination of information, technology and organic matter, which is located in the cross section of art, technology and science. Additionally to research papers, articles and book-chapters, the outcome of her artistic research is in artworks that deal with the merger of the technological and biological matter and intelligence. The research engages with areas such as human enhancement, biosemiotics, biological matter, artificial life (AL) and artificial intelligence (AI), robotics, and information technology in connection to art, humans and society. She was Professor at the Art Academy in Oslo 2002-06, Visiting Professor at The University of Applied Arts in Vienna 2009, 2011, a recipient of a prestigious 5-year artists grant by the Finnish State 2007-11, and currently she is Associate Professor and the Head of PhD School at IT University in Copenhagen.

Peter Blasser, designer and builder of synthesizers, practices deep consultation with clients who seek rich interactions with their electronics. The instruments manifest electronic modulations through pins, case flexure and radio fields. He teaches circuit design and instrument building in classes and workshops, culminating in performance or installation. Some paper circuits can be downloaded from his website, printed out and assembled to yield sound objects. The cybernetic interface uses the subtleties of touch, through discrete components, often woven together geometrically, to simulate intuitive patterns and chaotic sophistication. Philosophical concepts spur his designs, which acquire a narrative as they refine into essential analogue synthesizers. Peter completed his undergraduate studies in 2002 at Oberlin College with Tom Lopez, Gary Lee Nelson and Pauline Oliveros. In 2015, he completed a Masters in Composition at Wesleyan University, where he studied with David Behrman, Anthony Braxton and Ron Kuivila. http://ciat-lonbarde.net

James Coupe (http://jamescoupe.com) is an artist whose practice spans installation, video, internet and public art. Many of his projects utilize facial profiling , biometrics, and algorithmic processes in order to raise questions about the function of power, observation and visibility in contemporary surveillance society. Whether weaving together fictional narratives with real-time events (*recollector*, 2007), using algorithms to create demographically profiled communities (*Swarm*, 2013), or hiring Mechanical Turk workers to document their working days (*General Intellect*, 2015), his work consistently aims to make visible the people, places, systems, and landscapes that often remain hidden, ignored, or unseen. Recent commissions include the Toronto International Film Festival, the Henry Art Gallery, and the Abandon Normal Devices Festival. He has received grants and awards from Creative Capital, the Prix Ars Electronica and New Contemporaries. His work has been exhibited worldwide, including venues such as Camden Arts Centre, Parsons/The New School and ZKM. He is an Associate Professor at DXARTS, University of Washington.

Félix Guattari (1930-1992) was a French psychotherapist, philosopher, semiologist, and activist. He founded both schizoanalysis and ecosophy, and is best known for his intellectual collaborations with Gilles Deleuze, most notably Anti-Oedipus (1972) and A Thousand Plateaus (1980), the two volumes of Capitalism and Schizophrenia. Guattari was a leading thinker of what came to be called Post-structuralism and Post-Modernism. Trained as a psychoanalyst, Guattari trained as a psychoanalyst under Jacques Lacan and worked with at La Borde, a clinic near Paris that was noted for its innovative therapeutic practices from 1955-1992. He founded the review Recherches (1967-1983), connected to the Center for Institutional Study, Research, and Training (CERFI, 1965-1987), both of which combined transversal group work with research, knowledge production and political activism. Inspired by the student uprising in Paris in May 1968, Guattari collaborated with the French philosopher Gilles Deleuze (1925–1995) to produce a two-volume work of antipsychoanalytic social philosophy called Capitalism and Schizophrenia: Volume 1, Anti-Oedipus, and Volume 2, A Thousand Plateaus in 1972. This was followed by several collaborative publications with Gilles Deleuze, the last being "What is Philisophy?", which was published shortly before his death in 1992. Adapted from: https://en.wikipedia.org/wiki/Félix_Guattari (accessed: August 23, 2017)

Kathrine Elizabeth Lorena Johansson is a writer, a cultural theorist, independent researcher, university teacher, pedagogue of music and movement and workshop holder. She holds a masters in Modern Culture and Cultural Communication, and a Ph.D. from the Planetary Collegium (Roy Ascott), University of Plymouth, UK. Her project investigated artistic mixed- and augmented reality interfaces as communicational forms that appeal to transformed ways of understanding the human subject. She places a particular emphasis on human consciousness, and on oscillatory states between inner and outer presence, including the thesis of a wider sensory realm that that of the 5 gross senses. Kathrine's work is transdisciplinary, philosophical and speculative. It integrates Philosophy of Science, Cybersemiotics (Brier, 2008), biosemiotics, and case studies of Interactive Art Installations in an original way. Project: 'Subject and aesthetic interface – an inquiry into transformed subjectivities'. Kathrine is currently a scientific assistant, teaching Philosophy of Science and qualitative methodology at Copenhagen Business School. She is furthermore a developer of creative experimental workshops, exploring interactivity between humans from an embodied state of being.

Sang Lee studied architecture in Illinois Institute of Technology and University of Pennsylvania. He completed his PhD in Architecture at the Delft University of

Technology where he teaches architectural design and theory. Sang has contributed numerous papers and chapters to international conferences, journals, and books. He edited and published "The Domestic and the Foreign in Architecture" in 2007 and "Aesthetics of Sustainable Architecture" in 2011. Sang is currently preparing the monograph "Architecture in the Age of Apparatus-Centric Culture" forthcoming in 2018, and the compendium "Meta-Architecture: Algorithms, Sign Systems and Environments" forthcoming in 2019/2020. Sang has received several grant awards for his work and the affiliated institutions from the US Department of Education, the European Commission Directorate General for Education and Culture, the German Federal Cultural Foundation, the Netherlands Architecture Funds, and the Netherlands Creativity Funds. Sang founded the experimental practice, Aleatorix, in Rotterdam and Berlin that specializes in the research and design of intermodal media; augmented design techniques; and responsive multimedia installations. Aleatorix will feature its work in the Bauhausfest 2016-2017 and the Bauhaus centennial in 2019.

Dan Overholt is an Associate Professor at Aalborg University Copenhagen. His research interests include advanced technologies for interactive interfaces and novel audio signal processing algorithms, with a focus on new techniques for creating music and interactive sound. He is involved in the development of tangible interfaces and control strategies for processing human gestural inputs that allow interaction with of a variety of audiovisual systems. Dan is also a composer, improviser, inventor and instrument builder who performs internationally with his new musical instruments and custom sound synthesis and processing algorithms. Dr. Overholt received a PhD in Media Arts and Technology from the University of California, Santa Barbara, and a M.S. in Media Arts and Sciences from the Massachusetts Institute of Technology. He has about 40 peer-reviewed publications and two patents (one provisional).

Andrew Pickering is a leader in the field of science and technology studies. Having taught for many years at the University of Illinois at Urbana-Champaign, in 2007 he joined the University of Exeter, where he is now an emeritus professor. He is the author of 'Constructing Quarks: A Sociological History of Particle Physics,' 'The Mangle of Practice: Time, Agency and Science' and 'Kybernetik und Neue Ontologien,' and he is the editor of several collections of research essays, including 'Science as Practice and Culture,' 'The Mangle in Practice: Science, Society and Becoming' (with Keith Guzik) and 'Science as It Could Have Been: Discussing the Contingency/Inevitability Problem' (with Léna Soler and Emiliano Trizio). He has written on topics as diverse as post-World War II particle physics; mathematics, science and industry in the 19th-century; and science, technology and warfare in and since WWII. His latest book, 'The Cybernetic Brain: Sketches of Another Future' was published in 2010. It analyses cybernetics as a distinctive form of life spanning brain science, psychiatry, robotics, the theory of complex systems, management, politics, the arts, education, spirituality and the 1960s counterculture, and argues that cybernetics offers a promising alternative to currently hegemonic cultural formations. Growing out of his work on cybernetics, Pickering's current research focuses on art, agency, the environment and traditional Chinese philosophy.

Chris Salter is an artist, University Research Chair in New Media, Technology and the Senses at Concordia University and Co-Director of the Hexagram network for Research-Creation in Media Arts and Technology in Montreal. He studied philosophy and economics at Emory University and completed a PhD in directing/dramatic criticism at Stanford University where he also researched and studied at CCMRA. He collaborated with Peter Sellars and William Forsythe/Frankfurt Ballet. His work has been seen all over the world at such venues as the Venice Architecture Biennale, Chronus Art Center Shanghai, Wiener Festwochen, Berliner Festspiele, Muffathalle, Vitra Design Museum, HAU-Berlin, BIAN 2014, LABoral, Lille 3000, CTM Berlin, National Art Museum of China, Ars Electronica, Villette Numerique, Todays Art, Transmediale, EXIT Festival (Maison des Arts, Creteil-Paris) among many others. He is the author of *Entangled: Technology and the Transformation of Performance* (MIT Press, 2010) and *Alien Agency: Experimental Encounters with Art in the Making* (MIT Press, 2015).

Nicolas Schöffer (1912-1992) was a Hungarian-born French artist, considered the founder of cybernetic art. His career touched on painting, kinetic sculpture, architecture, urbanism, film, TV, and music. Indeed he collaborated on music with Pierre Henry. All of the artistic actions of Schöffer were done in the pursuit of a dynamism in art. This interest in artistic dynamism was originally initiated by the Cubo-Futurists and then intensified and solidified by the Constructivist artists, such as Naum Gabo, Anton Pevsner, Laszlo Moholy-Nagy and Ludwig Hirschfeld-Mack, who were concerned with opening up the static three-dimensional sculptural form to a fourth dimension of time and motion. Schöffer also benefited from cybernetic theories (theories of feedback systems primarily based on the ideas of Norbert Wiener) in that they suggested to him artistic processes in terms of the organization of the system manifesting it (e.g., the circular causality of feedback-loops). For Schöffer, this enabled cybernetics to elucidate complex artistic relationships from within the work itself. Consequently his kinetic sculptural compositions used an adaptation of cybernetics in formulating a creative epistemology concerned with the self-communication within an observer's psyche and between the psyche and the surrounding environment in order to create a subject/object polarity within the artistic experience. Adapted from: https://monoskop.org/Nicolas_Schöffer (accessed: August 23, 2017)

Edward A. Shanken writes and teaches about the nexus of art, science, engineering, and design with a focus on interdisciplinary practices involving new media. Books include Telematic Embrace: Visionary Theories of Art, Technology and Consciousness (University of California Press, 2003), Art and Electronic Media (Phaidon Press, 2009), Inventar el Futuro (2013), and Systems (Whitechapel/MIT Press, 2015). Dr. Shanken is an Associate Professor of Digital Arts and New Media at UC Santa Cruz. Prior academic posts include the Digital + Media MFA program at RISD, the DXARTS Ph.D. program at University of Washington, the New Media MA at University of Amsterdam, and Executive Director of Information Science + Information Studies at Duke University. Dr. Shanken earned a Ph.D. in Art History at Duke, an MBA at Yale University, and a BA in Fine Art at Haverford College. Many of his essays are accessible via his website: http://artexetra.com

Esben Bala Skouboe is a rewarded artist and PhD. civil engineer in Architecture & Design from Aalborg University, Denmark. His interests include a broad range of theoretical, conceptual as well as practical tools; such as responsive architecture, adaptive art and non-standard architectural forms, exemplified in the winning proposal for the pavilion project: Nora, displayed at the 10th Architectural Biennale in Venice. Esben has developed a series of art projects in the field of interactive art & architecture. Esben is founder of the studio Electrotexture Lab. presenting experimental art and architectural projects such a; Acoustic Pavilion, Red Pavilion, Danzer Light, and the project series Perceptual Ecologeis, all projects realised together with a network of artists, musicians, researchers, programmers and architects. Esbens work has been published at international exhibitions, conferences, in magazines and in curated book chapters. Today Esben also head the company Modos.

Heinz von Foerster (1911-2002) was an Austrian American scientist combining physics and philosophy, and widely attributed as the originator of Second-order cybernetics. He was twice a Guggenheim fellow (1956–57 and 1963–64) and also was a fellow of the American Association for the Advancement of Science, 1980. He is well known for his 1960 Doomsday equation formula published in Science predicting future population growth. As a polymath, he wrote nearly two hundred professional papers, gaining renown in fields from computer science and artificial intelligence to epistemology, and researched high-speed electronics and electro-optics switching devices as a physicist, and in biophysics, the study of memory and knowledge. He worked on cognition based on neurophysiology, mathematics, and philosophy and was called "one of the most consequential thinkers in the history of cybernetics". He came to the United States, and stayed after meeting with Warren Sturgis McCulloch, where he received funding from

The Pentagon to established the Biological Computer Laboratory, which built the first parallel computer, the Numa-Rete. Working with William Ross Ashby, one of the original Ratio Club members, and together with Warren McCulloch, Norbert Wiener, John von Neumann and Lawrence J. Fogel, Heinz von Foerster was an architect of cybernetics and one of the members of the Macy conferences, eventually becoming editor of its early proceedings alongside Hans-Lukas Teuber and Margaret Mead. source: https://en.wikipedia.org/wiki/Heinz_von_Foerster (accessed: August 23, 2017)

Graham Wakefield (worldmaking.github.io, artificialnature.net) is an artist, musician, and programmer, researching the generation of open-ended mixed-reality environments for exploratory experience, emphasizing continuation over closure. As Assistant Professor in the School of the Arts, Media, Performance, and Design (AMPD), and a Canada Research Chair (Tier II) in interactive information visualization, at York University, Toronto, Canada, he has founded the Alice lab for research and art practice in computational worldmaking. This lab is dedicated to the exploration of nature-inspired creativity and complexity within responsive computational worlds, experienced through emerging mixed/hybrid reality technologies including both virtual reality (VR) and augmented reality (AR). At York he is also a member of The Centre for Vision Research and Sensorium organized research units, and a core member of the Vision: Science to Applications Canada First Research Excellence program. He was previously an integral researcher at the AlloSphere, a unique 3-storey spherical multi-user virtual reality instrument at UC Santa Barbara 2007-2012, and a visiting professor at KAIST, Korea, and a software developer for Cycling '74, where he co-authored the Gen framework, now with tens of thousands of users and incorporation into curricula at a number of universities. Dr. Wakefield's art installations have been exhibited at leading international museums and peer-reviewed events in areas of digital media, computation and culture, including ZKM Karlsruhe, La Gaite Lyrique Paris, and SIGGRAPH, and have attained national and international awards including VIDA, the premier art & artificial life competition (2014).

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Worldmaking as Techné

PARTICIPATORY ART, MUSIC, AND ARCHITECTURE

Edited by Mark-David Hosale, Sana Murrani, and Alberto de Campo
with a Foreword by Roy Ascott

Worldmaking as Techné: Participatory Art, Music, and Architecture outlines a practice that challenges the World and how it could be through a kind of future-making, and/or *other* world making, by creating alternate realties as artworks that are simultaneously ontological propositions. In simplified terms the concept of *techné* is concerned with the art and craft of making. In particular a kind of practice that embodies the enactment of theoretical approach that helps determine the significance of the work, how it was made, and why. By positioning worldmaking as a kind of *techné*, we seek to create a discourse of art making as an enframing of the world that results in the expression of ontological propositions through the creation of art-worlds.

The volume focuses on the involvement of the *techné of worldmaking* in participatory art practice. Such practice can be found in all areas of art, however, under scrutiny for this particular book are: interactive, generative, and prosthetic art, architecture, and music practices that depend for their vitality and development on the participation of their observers.

The book is organized into three sections: *po(i)etic, machinic*, and *cybernetic*, which explore the aesthetics, systems, methods, and ontological underpinnings of a worldmaking based practice. Each section contains historical texts alongside new texts. The texts were carefully chosen to highlight the integration of theory and practice in their approach. While the foundation of this worldmaking is deeply philosophical and rigorous in its approach, there is a need to connect this work to the World of our everyday experience. As we contemplate issues of why we might want to make a world, we are confronted with the responsibilities of making the world as well.

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