ADVANCES IN CONSCIOUSNESS RESEARCH

The Postmodern Brain

Gordon Globus

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THE POSTMODERN BRAIN

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Volume 1

Gordon Globus

The Postmodern Brain

THE POSTMODERN BRAIN

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O hidden under the dove's wing,
hidden in the turtle's breast,
under the palmtree at noon,
under the running water,
at the still point of the turning world,
O hidden.

T.S. Eliot

Es gibt Sein. Es gibt Zeit.

M.Heidegger

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PREFACE N

> ...we have to begin somewhere without really knowing where. Which we have now done. But in beginning at the "beginning" we have, precisely, not begun at the beginning; everything had *already* begun.
>
> Geoffrey Bennington (Bennington and Derrida 1993, p.19)

This is the Nth "preface" and, like the others, written while the text is still in preparation. All of the chapters are Chapter Ns, for that matter. I have continually folded the book back into itself[1*] during succeeding revisions, which disrupts the conventional linear sequence and leaves temporary opacities. Postmodernism treasures nonseriality, surprise and an obscurity meant to draw one in, though modernistic readers often find this style discomforting and complain that there is no clearing. A postmodern text requires of the modernist the "willing suspension of disbelief," at least initially. Letting go of serial logic is, indeed, a bitter pill for the modernist, who is inclined to believe that there is no alternative.

My text brings together two regions of discourse: postmodernism and the brain sciences (mainly neuroscience, cognitive science, and psychiatry). Magnifying the border: I take two seminal figures in twentieth century continental philosophy as representative of postmodernism, Martin Heidegger and Jacques Derrida. I take the burgeoning field of nonlinear brain dynamics[2*] as representing the sciences of brain. This move is somewhat prospective, since the field is new, although its progenitor is the preSocratic philosopher, Heraclitus, who proclaimed "everything flows."[3] I attempt to show that Heidegger/Derrida postmodernism[4*] has an aspect that is coherent with nonlinear dynamical conceptions of brain functioning.[5*] I find symmetry between Heidegger/Derrida postmodernism and nonlinear brain dynamics. (I do not bridge postmodernism and nonlinear brain dynamics—"bridge" is a serial term—but disclose a resonance between them.)

Postmodernism resists defining for principled reasons. The wily Derrida never lets himself get pinned down; Geoffrey Bennington attempts a general description of Derrida's system of thought, and there is the irrepressible Derrida, writing in the margins of Bennington's text on Derrida his own counter-text (Bennington and Derrida, 1993). For postmodernism, discourse is flowing, ever-changing, without beginning or end, unowned. No concept can be held still,

inviolate, or proprietary in this spontaneous flood of discourse.

Postmodernism's enemy is clear enough, however: Heidegger and Derrida call it "metaphysics."[6*] Metaphysics for Heidegger begins with the Socratic philosophers of ancient Greece and continues uninterrupted to the present day, where it is expressed in technology. Prized descriptors of metaphysics, such as "logical" and "founded," become epithets in postmodern hands. Metaphysics brings forth dualities, which postmodernism denies. (Think of Descartes' subject/object, for example.) Metaphysics wants to possess certainty, which postmodernism says is impossible, and metaphysics abhors chaos, in which postmodernism revels. It is the all-pervasive metaphysical structure of our very language that Heidegger and Derrida "deconstruct."[7*] Representative of metaphysics in contemporary brain science is the theory that the brain computes, which will be deconstructed in this text.

My endeavor is not typical of postmodernism in an important sense, however. Mine is a justified postmodernism,[8*] rather than the relativistic postmodernism typical of critical theory where seemingly "anything goes." This justification is not based on reducing postmodernism to the sciences of the brain; it is an assertion of symmetry between them. (To find truth, I say, seek global symmetry, not local logic.[9*])

In training the anti-metaphysical, postmodern guns on the sciences of brain, it is the theory of brain functioning that is subject to deconstruction. The sciences of the brain are metaphysical by virtue of the idea that the brain processes information, i.e., logically computes. Brain science remains enthralled by the Greek *logos*. The very deep, nearly universal, scientific conviction that what the brain does is process information is to be surpassed by deconstructing the brain.[10*] So in the deconstructive phases of the text, brain information processing is exposed and rejected.

In the constructive phases, the concept of nonlinear brain dynamics is developed and related to postmodernism. A key idea here is that *in a self-organizing, nonlinear dynamical system that undergoes chaotic regimes, brain states evolve under tunable constraint*. The brain is *self-tuning* as it intersects with patterns of energy from the surround: the brain brings its own attunement to interactions with nonbrain, with other, with the world surround—and a flowing trajectory of states results. I identify self-tuning with cognition.

Now breaching as I do the great and hostile gulf between postmodernism and cutting-edge science, I tend to get it good from both sides, and end up the proverbial bloodied peacemaker (if I may play upon your sympathies). I am something of an old dog, trained as a scientist, and I cheerfully concede that there is more than a trace of modernism that taints this text, which my clever postmodern critics will seize on to discredit the ideas presented here. (I am but a "high-modernist," sniffed one postmodern maven on reading chapter seven.) However, I prefer to think of myself as something of a blue-collar postmodernist—hands dirtied

at the research bench and in the clinical encounter—but with my heart in the right place. The result, as Harry Hunt observes, is a "cubist" writing style that juxtaposes the playful and self-questioning vs. the literal and certain. These sometimes jarring shifts between science talk and postmodern talk disclose a necessary disruption when one endeavors to be both scientific and postmodern. Tolerance for this condition must be cultivated against the lulling, seamless continuity of modernism.

Scientists might be disdainful that my theory is not immediately testable at the laboratory bench. Here I plead that my endeavor is oriented toward critiquing the paradigm within which brain science procedes and opening for discussion an alternative paradigm with postmodern proclivities. If scientists could but overthrow the computational framework that constricts their thought and look at the brain in a fresh way, a revolution in scientific praxis would follow apace.

It may be helpful in locating the present interdisciplinary text to say something of major influences on it. Hubert Dreyfus' (1979, 1992) superb critiques of artificial intelligence from a Heideggerian and Merleau-Pontian perspective opened a path. Dreyfus' achievement was mainly critical, but it raises the constructive question: If computers can't do what we "Daseins" can, as Dreyfus shows, then maybe some other kind of system has the right stuff. I shall propose that nonlinear dynamical systems can do what we can. David Bohm's (1980) discussions of dynamical holonomy—the dynamical law of the whole—in which there is a movement of enfolding to the whole (the implicate order) and unfolding from the whole (the explicate order) have opened up a different way of thinking, indeed, a paradigm change. Since Bohm was influenced by J. Krishnamurti's non-western transpersonal teachings (e.g., Krishnamurti and Bohm [1985]), a spiritual dimension enters here as well. (See also J. David Peat,[11] who is greatly influenced by Bohm.) Francisco Varela[12] aroused me from dogmatic slumbers to see that the brain does not represent the world. His seminal concept of "autopoiesis" was also influential.[13] Autopoiesis is a process through which living systems form and sustain their own boundaries and maintain these boundaries when perturbated. Prigogine's work[14] on complex systems at far from equilibrium conditions was also most stimulating. The work of the physicist Kunio Yasue[15] was very influential toward the end of this writing and forced the bifurcation that is chapter eight. Karl Pribram[16] had steadfastly argued that we should think of brain functioning in wave terms. Yasue and coworkers lucidly showed that brain dynamics could be described by a neural wave equation of the same form as the famous Schrödinger equation in quantum physics. Finally, Heidegger and Derrida have been crucial to the present work, in which all of these influences cohere.

Six of the chapters have previously appeared in specialty journals in the fields of psychology, philosophy, cognitive science and psychiatry.[17] I have attempted, with the editorial assistance of Donna Skelton, extensive revision of most of these chapters to make them not only more coherent but accessible to a general, multidisciplinary audience. Such an endeavor cannot be entirely successful.

For example, the neuroscientist is inevitably going to have difficulty with chapter three on Heidegger and Derrida, which the philosopher may find too simplified, whereas the roles are reversed in chapters four and eight, which focus on cognitive neuroscience. Fortunately, it is possible to skip chapters since the book keeps folding back into itself, rather than progressing in serial fashion.

There is some planned redundancy in the text, with which some may be impatient. I have followed this strategy because of the power of the prevailing paradigm, which inevitably leads to assimilating my proposal to conventional thought and, thus, to deep misunderstanding. With repetition, the difference sinks in. Furthermore, a single presentation within a particular context leads to a superficial, circumscribed understanding. What appears redundant in the text is usually placed within a different context, so that the understanding broadens and new relationships are seen. (My own style of reading is to engage a few very good texts repeatedly, rather than many texts once, so I am quite at peace with repetition that ripens understanding.)

Some miscellaneous points: The automatic indexing program of Word 6.0 proved unreliable. (A pox on Microsoft Corporation.) I have not compulsively inserted citations in the text, when the citation is obvious or cumbersome, to make the text easier to read. A superscript marked with an asterisk indicates that the footnote contains a definition or elaboration, whereas unmarked superscripts are only citations. I often use non-English words and phrases and provide the translation in parentheses or footnotes. English terms are so encumbered with connotations for the English reader that one can more sharply locate the concept and better hear its resonance with other concepts by substituting non-English terms. "Existence," for example, is hackneyed and overloaded with meanings I don't intend to convey, whereas *Existenz* is sharply etched. It is postmodern *Existenz* and nonlinear dynamical brain functioning that are written here.

CHAPTER ONE

THE UNEXPURGATED SELF-ORGANIZING DREAM

Since we have to begin somewhere, without knowing where, let's pick a place of feeling rather than logic. Feeling marks places of tension in discourse, where something important enough is at stake that people care. Making an incision here, a core conflict is exposed.

*

The controversial French philosopher and critical theorist, Jacques Derrida, has exploited the possibilities of philosophical polemics against the American philosopher, John Searle, and in cheerful enough fashion.[1] *Polemikos* means war, as between the French and the Anglo-Saxons, and war brings self-definition in the process of conflict. A concept is meaningful only in relation to other concepts, especially its opposite which it tries to dominate, and these other concepts have their own relations with still other concepts and, ultimately, with the whole.[2] Concepts do not stand alone, self-sufficiently. So concepts at war in fiery polemics light up a conceptual region, whereas in the dark night of peace, a concept appears to stand smugly alone in the light of its spurious plenitude.

Some even find it strategic to live their lives polemically, in concert with a "worthy adversary."[3] We learn best who we are from our opponents, not our kindly collaborators who reinforce our own self-image, invincible or self-pitying as the case may be. In pressing against the other, a boundary is evinced.

The eruption of polemics within discourse leaves an affective trace of forces in conflict. Of course, not all polemics are open. Backstage, behind the play of the most irenic published manuscript, there may be a small *polemikos* going on, which is likely to be far more interesting and informative than the scene of the written page. The issues left filed behind the published manuscript may even be symptomatic of the hegemony of the dominating tradition.

Editorial correspondence is by convention considered entirely marginal to the text, but it is in the margins that deconstruction finds its most suggestive material. Of course, all traces of the interaction between author and editor are erased from the margins of a printed text. In this chapter, however, I restore the editorial margins of a published manuscript. The emotionality of a theme—pro and

con—is revealed in the polemic disclosed. In implementing deconstruction, a hidden emotional issue, flagged by marginal polemics, is an attractive place for incision.

*****

Out of the blue one day, I received a letter from the editor of an official American Psychological Association journal devoted to "humanistic psychology" which enclosed a review of my last book, *Dream Life, Wake Life*. The letter invited me to write a "reply" to the review. But the editor noted that since the review was generally quite positive, nothing contentious was called for in my response. He suggested that I use the review "as a springboard for any further reflection or application of your work." So I happily took this *carte blanche* as an opportunity to get my latest thoughts on stage.

My fantasy was to bring very good news to humanistic psychologists. They're gonna love this text! Maybe *programmed* computers can't do what humans can, as Hubert Dreyfus (1992) has shown, but the *self-organizing* neural networks of connectionism might have that potential. Maybe our brains are not computer-like but are akin to these connectionist engines, functioning according to radically different principles (which principle will be elucidated in the unfolding of this book). Dreams are a fruitful area to explore alternative notions about the brain, for in dreams we see a spontaneous and creative process at work, and it is precisely here that computer conceptions are disadvantaged.

We shall see how dreams depend on self-organizing nets operating under the special conditions that obtain during sleep. Neural nets just might have the right stuff to do what human beings do, or so I claim, and ought to be enthusiastically embraced by humanists at large. It is possible to be both humanistic and physiological. So it is in the spirit of peace that I sent my reply to the editor. I fantasized that I could build a stout connection between brain scientists and the artificial intelligentsia on the one hand and my pals, the humanistic psychologists, on the other. But suddenly, into this happy reverie erupted *Polemikos*!

*

Dear Dr. Globus,

As I wrote you after receiving it, your reply to the review of your book did arrive just in time to include in the Autumn issue. I had invited it in the hope of being able to publish both the book review and your reply back-to-back in the same issue. Unfortunately upon reading your reply, I concluded it would be best to postpone publication of both pieces until after I could confer with you. I do so now,

with an unadorned frankness, based on respect for you as one engaged in intellectual discourse.

I was quite surprised to see the direction your thought has taken in your reply. As you yourself acknowledge in its introductory paragraph, your portrayal of dreaming has taken a shockingly mechanistic turn. As you say, such a turn is disturbing to humanistic psychologists. Indeed, your mechanism leaves no room even for meaning or intentionality any more, thereby abandoning the psychoanalytic and phenomenological roots of your earlier book. To reduce the dream to neuronal activity is to commit the very psychologists' fallacy that Freud and phenomenology so acutely undermined. The physiology does not establish the meaning of the dream, it evinces it. Though your own physiological mechanisms are more up to date, I fear you've simply put old wine into new bottles. The bottles are surely shinier, but the wine is just as stale.

I was especially surprised to see you characterize this turn as one from a Husserlian to a Heideggerian account of dreaming. There is an active daseinsanalytic psychology of dreaming that is derived directly from Heidegger, which I must say would completely disavow any relation with your conception...

I appreciate your having included a dream as illustration. However, I am sure that, freed from the constrictions of your new theory, you could have reaped a much richer harvest from such a fascinating dream. It would be quite interesting to see a fully worked out daseinsanalytic description of it.

This unexpected turn in your thinking leaves me in a quandary. I still believe your book is a valuable contribution of real interest to my readers. However, it would not be appropriate to devote space to your new theory of dreaming, since it is actually anti-humanistic. [Various solutions are proposed, including publishing a humanistic rebuttal.] Let me know what you think of these possibilities, and any others you can propose.

In closing, I hope you have not felt offended or insulted by my remarks, but take them in the spirit of intellectual exchange in which they are intended. The emotion you may discern in them is my very real disappointment upon discovering the evolution of your thought. May I hope that it is a way-station on a trajectory that will take you beyond physiology and back to meaning?

The Editor

*

This editor is definitely a worthy opponent! He tells me my thought is stale and quite unrelated to humanistic psychology. I am even incapable of analyzing my own dream! Indeed I am "anti-humanistic," the enemy, *other*. And imposing a beautiful double bind: I should not be offended but take this assault in the spirit of intellectual exchange. My *riposte* is the present chapter, in which I join the polemic

in full howl.

*

Dear Editor,

On returning from some time away—my mother passed, as presaged in the dream—I found your surprising letter, as if I were a weasel in the humanistic chicken house! I truly am unaware that I have fallen off the path; it appears as a continuous evolution to me.

I have clarified and expanded somewhat my manuscript but I suspect that it will not make you any happier. The problem, it seems to me, is that you do not want to extend recognition to a recent development in existential thought. This development admits traffic between existence and cognitive science. It was founded by Hubert Dreyfus at Berkeley. Francisco Varela at the Ecole Polytechnique in Paris, Terry Winograd at Stanford, and Fernando Flores have also contributed. I too have written along these lines, so my manuscript is not really a departure from my previous position, including my book *Dream Life, Wake Life*.

If I may say so, I think you over-reacted to my manuscript. It is not "anti-humanistic" but a variation of the humanism to which you are committed. In Heideggerian terms, this is a "re-trieve," thinking what cannot be thought in the tradition. I take it that your aversion to what I had to say made it impossible to sense what I called the "great beauty" of holistic, spontaneous, self-organizing networks. I rather doubt that I am alone in my aesthetic. Whether my manuscript ultimately proves right or wrong, it would seem at least worth considering by your readers.

It is perfectly acceptable to me, indeed of great interest, that you publish a reply to my piece.

Sincerely,

Gordon Globus, M.D.
Professor of Psychiatry and Philosophy

*

This time I submitted a tougher version, but when it was finally published many months later, the original version was used. There was no humanistic rebuttal, but instead the manuscript had been edited and mitigated by the editor. My text was partially erased. For example, the crescendo of my last paragraph was lopped off. But, of course, the editor's hand has been effaced in the presenting of a text whose margins are clear. I let loose a loud *Geschrei* to the editor, and he responded that

my reply was longer than the review, he only pruned redundancies anyway, and I should be grateful for all the space he gave me.

Definitely a worthy opponent. In focusing my attention on the implication that my model was mechanistic and reductionistic, indeed counter to deeply rooted humanistic conceptions of the human spirit, he forced me into a deeper exploration of human neurophysiology and human existence. Here is the *un*expurgated second version of the published piece, edited slightly for purposes of clarification.[4*]

THE SELF-ORGANIZING DREAM

I want here to develop further some ideas in my book, *Dream Life, Wake Life*. My discussion will be more physiological than humanistic psychologists typically like to consider. But in the new neural network conceptions of the brain machinery, there are holistic processes of great beauty, which are quite unlike the dumb, brute, mechanical force of powerful digital computers. It is true that given the constraints of current technology, these holistic processes are usually simulated on digital computers. But the simulation is only cumbersomely accomplished for complex perceptual tasks; the computer crunches on for hours to get results that brain networks achieve in a few hundred milleseconds. To mitigate this mechanistic-sounding discussion, I shall illustrate the self-organizing dream with dream material.

My physiological bent in an earlier version of this piece led to some chiding and the appellation "anti-humanistic," so I bristle a bit in the present version. My view, which is interdisciplinary in spirit rather than purely humanistic, holds that the absurdity of considering together existence (*Existenz*) and machine is just that the technological exemplar on the machine side—the digital computer—has been the wrong kind of machine. A machine with "the right stuff"—a machine that might be spontaneous, unpredictable and creative, quite unlike our usual image of machines—ought to be embraced by humanistic psychologists; a graceful rapprochement with a burgeoning cognitive science is possible.

This approach was given great impetus by Dreyfus' Heideggerian critique of artificial intelligence (AI) in his seminal work *What computers can't do*. (Merleau-Ponty might be read as a progenitor.) Dreyfus does not decry the relevance of mechanism, only the current AI approach and hubris. Other relevant existential/cognitive science work includes Winograd and Flores' *Understanding Computers and Cognition: A New Foundation for Design* and Varela, Thompson and Rosch's *The Embodied Mind*. I have variously considered the development of an existential functionalism, Heidegger's analytic of Dasein in brain terms, Derrida and connectionism, and the existential version of the old "mind-body problem," i.e., the existence/brain problem.[5] Whether this body of continental philosophy/cognitive science/brain science work will ultimately prove viable remains to be seen, but surely it merits a hearing rather than dogmatic rejection.

So much for justifying consideration of the machinery of the brain. Now in my book I draw a sharp distinction between transformative and formative creativity. In transformative creation, some given elements are rearranged into a novel configuration (like symbols in a formula transformed according to logical rules and resulting in a new theorem). Freud's theory of dream construction is transformative: copies of waking life retained in memory are the raw elements composited by the dream work into the dream life by means of a "primary process" logic. The dream is thus a second-hand product, a collage of memories from different places and times configured into a dream narrative. Such transformative operations in which given elements (symbols) are arranged and rearranged are the hallmark of the "computational theory of mind,"[6] which looks to the digital computer for its defining technology.

For the computational theory of mind, thinking makes use of mental representations that are logically transformed, similar to the way that input data to the computer are logically transformed to output according to the rules of the program. In this model, logic is the governing factor in mental functioning, and the brain is conceived as inherently logical, like the computer.

It is crucial to appreciate that the computational theory of mind is "functionalistic." According to functionalism, the silicon elements of the computer and the neural tissue of the brain are functionally equivalent, since they both compute the same input-output functions on the basis of rule-governed transformations. (How this is actually done, by silicon or by neurons, is not of concern to functionalists.) "Mind" is equated with the program of rules. Functionalists are according comfortable in speaking of the "mind/brain."

Formative creativity, in contrast, is not provided any elements that might serve as "stuff" for the composition but spontaneously creates the whole product. This theory does not deny that waking life experiences are crucial to dream formation. However, *contra* Freud, there are no copies of actual life experiences, no little pictures of the past that are composited in the dream experience.

The dream is formatively generated in a primary creative act in which it may happen that experiences from the past appear in a new context. Rather than being composited from pictures of the past or constructed from a primitive stuff (*hyle*), there is a *holoworld* that enfolds all possible worlds and a particular dream world is selected for unfolding to concrete, explicate existence.[7*] This holoworld that enfolds all possibilities is itself generated by perfectly general means (as a convolution of numerous random waves of varying frequency, amplitude and phase). This convolution has such richness that all possibilities are contained therein, not like a Pandora's box filled with butterfly worlds but contained implicately, as enfolded worlds, interpenetrated in the whole. Meanings which have been operative during waking life act as selection rules in this process of creating dreams.

The account provided in *Dream Life, Wake Life*, however, retains a certain computational commitment to rule-following (i.e., selection rules for unfolding

enfolded worlds from the holoworld of interpenetrated worlds). I want to free that account from rule-following here, and in a more Heideggerian vein conceive of formative creativity as a spontaneous self-organizing process, an "upsurge of Being," if you will.

1. Self-organizing neural networks

The central concepts of self-organizing neural networks which are realized by connectionist technology are as follows. The state of the net is defined by the activity level of the silicon "neurons" comprising the net, i.e., how activated or deactivated the various neurons are. Neuronal output thus gives the state. Neurons comprising the network are richly interconnected; there is a many-to-one-to-many connectivity. Thus neurons are "nodes" of interconnection in a web. Each connection is excitatory or inhibitory and carries a "weight," which determines how much excitatory or inhibitory influence passes through the connection. The knowledge of the networks is carried by the matrix of connection weights which *constrain* the network's response to input. In learning these weights are adjusted.

The networks are also continuously *tuned*, which further constrains their responsivity. The networks become attuned for possible worlds; their attunement encodes a horizon of meanings that prescribe the inputs to which the nets will resonate. There are accordingly at least two kinds of constraints on network functioning: One constraint is the moment-to-moment meanings that tune the nets; the second constraint is the memory trace of past learning which is structurally encoded in the connection weights.

A network is *perturbed* by its input.[8*] Because of the rich interconnectivity, the input signal is distributed throughout the whole network, and the neurons operate globally in parallel (rather than the serial local processing of traditional digital computers). So when perturbed by input, the network begins to organize itself under the twin constraints of its tuning (meaning) and connection weights (learning). (The pattern of perturbation can also be treated as a constraint.)

The guiding principle of this self-organizing process is that changes in the network move toward reducing a certain global quantity over the whole network, which can be thought of as a kind of energy. As Smolensky (1986) brings out in his discussion of what he terms "harmony theory," this movement is to be understood as a relaxation toward *self-consistency*; I shall label this movement the "harmony principle." No rules are followed; there is no program of serial steps. Instead the whole interconnected network fires away, and a self-consistent state gradually "settles out." This image of "settling" or "relaxation," which comes from the literature of neural network research, is too static: there is a flow of states, which may briefly settle, given fluctuating tuning and input signals—all under the harmony principle. This holistic movement under the harmony principle is spontaneous and

results in changes in the network state. This model contrasts sharply with the rigid serial steps under absolute control by the central processor of a computer. The network under constraint is limited to a range of possible worlds, but is spontaneous within that range.

The analogy can be made to a political process in which conflicting groups communicate back and forth, each compromising while keeping its own requirements in mind, until some good enough consensus is achieved and a deal is agreed upon. In the network analogy, each group's requirement is a constraint to be satisfied and communication is the influence that passes back and forth between richly interconnected neurons. The political process is self-organizing and results in a compromise settlement. Thus the harmony principle achieves a kind of global community consensus that well-satisfies the constraints. To the extent that the various, typically conflicting, constraints can be satisfied, the network is "self-consistent."

The application of this connectionist theory to memory is important to the theory of dreams. Memories, e.g., what one had for breakfast, are not encoded as such; what is encoded is a constraint that the network may satisfy by settling into that state which is the remembering of what one had for breakfast. This encoding—the "memory trace" as such—takes place in the connection weights, which determine the degree to which influence passes the connection. When a proper input perturbs the constrained network, it relaxes into a state that is the remembrance. *Memories are thus created*, generated out of the spontaneously self-organizing process.

In general, the constraint structure that is a function of both the matrix of learned connection strengths and tuning sets up possibilities. Input to the network also constrains it; the input constraint is distinguished by saying that it "poses a problem," but formally it is a constraint to be satisfied like the tunable connection weights. Depending on the input and the other constraints, the network spontaneously settles into a particular state that is the formative actuality.

The relation here between the possible and the actual can be illustrated with dice. As we continuously shake the dice, various outcomes are possible, but when we finally roll them and particular die settle out, one of the possible states becomes actual. This example captures the idea of possibility and actuality, but the creativity here is transformative, not formative. For the example to be formative, the dice would have to erupt into being in the very act of throwing.

In the case of neural networks, the possibilities are states the net might settle into, whereas actualities are the states that settle out of the self-organizing process under constraint. In formative creativity, then, a possibility is actualized, whereas in transformative creativity, something already actual is changed into something else that is actual.

2. A dream of three beetles

Let's give this abstract discussion some immediacy by discussing a dream. This discussion is an invitation to the reader to consider in self-organizing terms his or her own dreams.

I dream that I am watching three beetles partly crawling down, and partly carried along by, a thin stream winding through a city street. The stream is a sort of mucky fecund trickle. I know (in that peculiarly certain way of dream knowing) that one of the beetles is my mother and another is my aunt. At the same time, there is a lively party going on in an apartment on the street, and my cousin Melvin seems to be the host. I alternate several times between participating in the party and watching the slow progress of the three beetles. Finally I can't find the beetles, which have disappeared into the stream, and I know that they have died. I am filled with grieving and wake up. I immediately think of "scarabs."

Some recent events spontaneously come to mind in connection with this dream. A few days previously I had talked with my mother's physician who gave me a disturbing report. My elderly mother was functioning at home as well as could be expected, but her physical condition was very fragile. She could die at any moment, he said. My mother lives with her older sister, my aunt, who also appears to be at the end of her life. Cousin Melvin is my aunt's son. I haven't seen him for many years. My mother has recently told me that he is going to have a big 60th birthday party. Since my mother and my aunt married brothers, my relationship with Melvin was close in childhood. Melvin was for me an older brother. When my mother and aunt die, Melvin and I will be the male family elders.

The day of the dream, I had noticed the name "Beetlejuice" on a theatre marquee as I drove by. I had puzzled for a few moments if this film was about the Beatles, but then realized the difference in spelling. Of course, John Lennon is dead, and there are only three Beatles left.

I am quite uncertain about what "scarabs" are at the time of awakening. I think they are a kind of beetle of significance in ancient Egypt, but I can't remember anything else about them, although I must have read about them at some time or other. While interpreting the dream, I read in the encyclopedia that scarabs are dung beetles that symbolized to the ancient Egyptians the cyclical process of regeneration.

Now Egypt has a special significance for me. When I visited the Coptic Museum in Cairo, I was startled to "see my eyes," with their dark pigmentation underneath, in the figures. (I have my mother's eyes in this regard. Eyes are especially significant for me at present in that my stoical mother's only complaint is that she is almost blind.) The Copts trace their lineage to the ancient Egyptians. In my conscious fantasy of specialness, I have Egyptian blood and relate myself to the time of Moses.

I interpret this dream as follows. In the dream I alternate between the lively party of a life which is death-denying and preoccupation with my mother and aunt's

progress towards death. The fecund stream symbolizes primordial life, and the scarabs in the stream symbolize the movement of the continually regenerating life-cycle, in which Melvin and I will head our genetic line toward death. In the face of my grief over my mother's impending death and in the face of my own death anxiety, the dream wisely points to the overarching life process of family and of a people in which I participate.

3. The self-organizing dream

This dream can be understood in self-organizing terms. (See Flow Diagram 1.1.) At the end of the day certain of my meanings are especially salient, having to do with mother, aunt, cousin Melvin, parties, eyes and death. What Freud called an "indifferent" impression from the day that seemingly lacks emotional value—here "Beetlejuice"—also had special significance. The Beatles are for me closely connected with death—an association to John Lennon's death—which further reinforces the salience of beetles. Melvin's 60th birthday party as a culturally defined life turning-point also has a salient meaning for me: after my mother and aunt's death, it will be Melvin's and my turn next.

All of these meanings in their salience have low thresholds of arousal; that is, they are easily elicited. They are automatically activated by nonspecific (noisy) stimulation from lower brain centers, which diffusely activate the cerebral cortex during REM sleep.[9] Meanings having to do with mother, aunt, cousin, party, eyes, death, Beatles and beetles tune and constrain the neural networks. Background knowledge encoded in the connection weights also serve as network constraints. Perturbed by the nonspecific, pontine brain stem signals, the networks thus constrained automatically move toward a harmonious, self-consistent state that achieves a good enough consensus across the constraints which reconciles life and death.

Given my life situation, the problem posed for the networks has to do with death and its relation to the various figures in my life. There is no unconscious intelligence, no "wisdom of the species" personified in the archetype of the Wise Old Man, that is sending me a message of how to deal with this problem, as Jung thought. Instead the networks spontaneously move toward harmonious self-consistency: the "wisdom" is akin to that of a rubber band that spontaneously relaxes after it has been stretched, but of course the neural system is much more complex. *This spontaneous movement under the harmony principle provides the dream.* The best solution to my problem is spontaneously generated by this self-organizing process. I can attain harmony in the face of death-loss and death-anxiety through resolute participation in the life cycle of death and birth in my family and in my people. The solution poignantly unveiled in my dream is surely

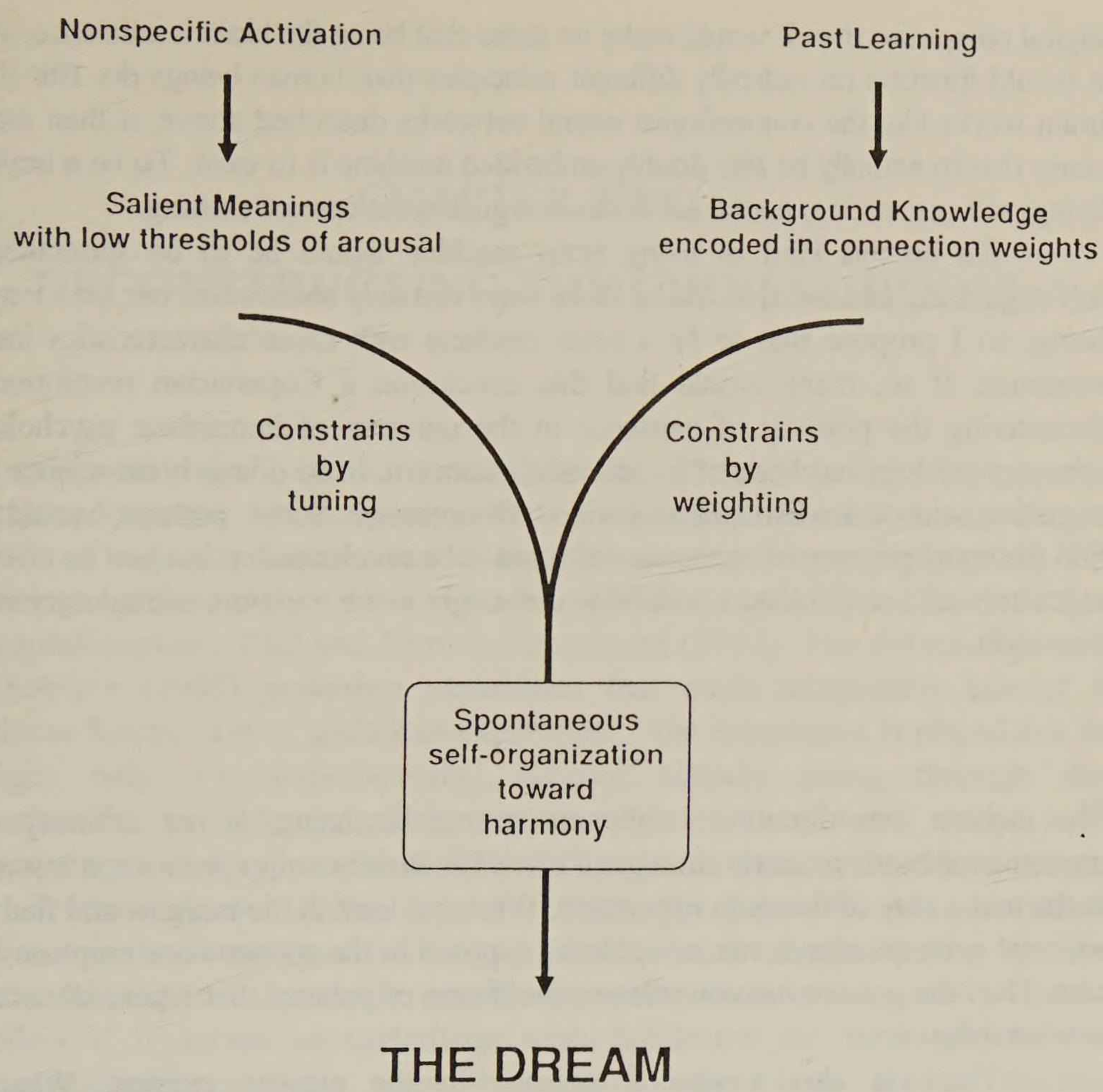

Figure 1.1: Flow diagram of self-organizing dream production.

better, deeper and has more impact than anything I came to in waking, where I mainly avoided the whole problem.

Viewing the dream in this way, as a self-organizing process, is both humanistic and biological. Let's consider what is entailed.

4. To be a self-organizing brain

The brain machine is doubly-embedded, first in the body which is, in turn, embedded in a physical energy sea. What is it *to be* that doubly-embedded brain? My suggestion is that *to be the doubly-embedded brain is to exist.* If the brain is like the

digital computer, then it would make no sense that being the brain is existence, since it would function on radically different principles than human beings do. But if the brain works like the connectionist neural networks described above, it then makes sense that to actually be *this* doubly-embedded machine is to exist. To be a brain of living, self-organizing, neural networks is arguably the case of existing.

To be this kind of living brain machine would be to be spontaneous, self-organizing and creative. To be those ways certainly sounds like our own way of being, so I propose that *to be* a brain machine with those characteristics just is existence. If so, many would find this conclusion a Copernician revolution in decentering the primacy of existence in the universe of humanistic psychology, where physiology has been of far secondary concern. In so doing, brain science and cognitive science are brought to parity with ontology. Some, perhaps, would not find the equal primacy of existence and brain to be revolutionary, but just an attempt at "re-trieve," i.e., thinking a possibility unthought in the tradition, and salutary in its own right.

*

The incision into discourse, while not a true beginning, is not arbitrary and unmotivated but is properly strategic. *Polemikos* already writes *polarity*; it inscribes in the text a play of forces in opposition. When we look in the margins and find the editorial correspondence, we see polarity exposed in the spontaneous eruption of a war. Thus the present incision releases the theme of polarity that repeatedly erupts in what follows.

There is also a general salience to the present incision. What is unequivocally evident—whatever the score card on the polemic—is that strong feelings are aroused; intense emotional opposition marks the region in discourse space where "existence" and "living brain machine" might come together. This marginal mark of polemical opposition is a symptom, calling for further investigation; the unanticipated emotionality locates a potentially rewarding place for deconstructive incision. The flare up of conflict in the textual movement described in this chapter lights up a path, a spur that beckons toward dark regions of discourse space.

CHAPTER TWO

DECONSTRUCTING THE CHINESE ROOM

The "deconstructive" eye is attracted to the social fact that the popular magazine *Scientific American* has published a debate on whether computers are capable of understanding; the two sides of the question were represented by the Berkeley philosopher, John Searle (1990), and the San Diego neurophilosophers, Paul and Patricia Churchland (1990). The debate focussed on Searle's (1980) *gedanken* experiment that made imaginative use of a "Chinese Room." (In a "gedanken experiment," the experiment is played out in thought only, i.e. hypothetically, without actually going through the experimental procedures.) This experiment, together with many peer commentaries, had appeared initially some ten years earlier in a major journal, *The Behavioral and Brain Sciences*. Since the argument has continued unabated in the literature without sign of resolution, the deconstructive eye has a watchful glint to it. Just as the psychiatrist noting an unremitting marital battle wonders if it serves an underlying wish fulfillment for both parties, the deconstructionist suspects something hidden when texts are in chronic unresolved conflict. Perhaps there is an effaced complicity in the vicinity of the Chinese Room; the two sides are in secret modernistic agreement, but neither wants to look at it, so the commotion keeps going.

"Deconstruction" is a controversial and highly irreverent postmodern technique in philosophy and literary criticism that has sprung forth notably in the *oeuvre* (body of writing) of the contemporary French philosopher, Jacques Derrida, although its roots lie in Heidegger's critique of the western tradition of dualism, which he traces backward from the 20th century, through Descartes, to the time of the Socratic philosophers in ancient Greece.[1] Heidegger and Derrida call this dualistic tradition *metaphysics*; from the 17th century on, it can be called *modernity*. Of course, those within the metaphysical tradition castigated by Heidegger and Derrida have their own dualistic targets that they label "metaphysics," and in the spiritual literature "metaphysics" means something else again, which is thought to be good—because beyond the crass physical. But wherever the term crops up in the present book, 'metaphysics' refers to the mainstream western philosophical tradition which has infiltrated common sense and has become embedded in our language, so we are obliged to

speak metaphysically in everyday discourse. Thus our sentence structures typically have a subject and an object: a "doer" and a "done to," so to speak.

The historical form this tradition takes—the *Gestell*, in Heidegger's lexicon—is currently technological;[2] that is, in our own epoch, technology, notably computer technology, dominates contemporary thought. We are so thoroughly immersed in this "metaphysical" tradition with its various dualities (such as subject/object, immanent/transcendent, spirit/matter, inside/outside, sensible/intelligible, origin/end, center/periphery and presence/absence) that the very language used in deconstruction cannot be free of it. (Thus Heidegger literally places a cross over certain metaphysical words that he cannot avoid using, e.g., Being, thus both using the term and crossing it out. When Derrida is obliged to use metaphysical words, he does so "under erasure" (*sous rature*), which is a process of unthinking thought.) Like the eye that cannot see itself, the modern mind abides unquestioningly in the traditional metaphysical context with its various dualities. This makes it difficult to define metaphysics at the outset of the present discussion; instead it shall come into view as the deconstruction proceeds.

A written text may show peculiar symptoms of the strain resulting from tacit metaphysical commitments, symptoms which deconstruction seeks out as incision points for discussion. Deconstruction scans the footnotes of the text, rhetorical flourishes, metaphors, format and such seemingly insignificant "marginalia," which are completely passed over in conventional readings.[3] For example, in his polemic with Searle, Derrida focuses on the copyright that Searle had placed on the cover page of a pre-publication manuscript, in order to deconstruct the metaphysical notion that texts have a true, authoritative meaning that can be transmitted by the writer.[4] There is no authorial primacy as to the interpretation of the text, that is, once it has entered discourse, anyone can appropriate the text for his or her own use. (Such appropriation of what the author considers personal property leads to outrage and has given deconstructionism a bad name.)

The symptom that attracts the present deconstruction is the prolonged unresolved controversy over the Chinese Room. This controversy is normalized in a modernistic publication vehicle that glorifies science and technology and thus sustains the tradition. The deconstructionist, then, looks for some hidden agreement that maintains metaphysics in the vicinity of scientific America's Chinese Room, some complicity which is submerged in the turmoil.

1. The story of the Chinese Room

John Searle (1990, p. 26) does not understand Chinese writing, which to him "looks like so many meaningless squiggles." He supposes being put away inside a room that contains baskets full of Chinese symbols and a rule book written in English for matching Chinese symbols with other Chinese symbols. (The deconstructive ear hears the metaphysical duality in this unfolding story: there is an *inside* the Chinese Room and an *outside* of the Chinese Room that structures the story throughout.) The rules identify the symbols entirely by their shape; the symbols are individuated purely by their graphic pattern, rather than any meaning. Thus these meaningless symbols are purely "syntactic." (This is *not* the standard grammatical sense of "syntax" but a technical usage, referring to purely formal patterned properties of marks on the page; symbols are individuated by purely physical properties.) The rules say such things as, "Take a squiggle-squiggle sign from basket number one and put it next to a squoggle-squoggle sign from basket number two" (p. 26).

Outside the Chinese Room there are people who understand Chinese and who pass questions in Chinese script to Searle inside the room. Searle consults his rule book and constructs a Chinese answer which is, of course, completely meaningless to him. But the rule book has been constructed in such a way that when the answer is passed outside the Chinese Room, the people who understand Chinese find Searle's answer plausible. Searle has passed the so-called Turing Test, in that his behavior is indistinguishable from that of a person who does understand Chinese. (In the Turing Test, a computer whose responses to questions cannot be distinguished from human responses is counted as understanding the questions.)

Now Searle says triumphantly, my situation in the Chinese Room is just the situation of a computer. I am like a computer and the rule book is my program. Both I and a computer "merely manipulate formal symbols [syntax] according to rules in the program" (p. 26, brackets added). "Like a computer, I manipulate symbols, but I attach no meaning to the symbols" (p. 26). Since Searle does not understand Chinese, it cannot be said that a computer could understand Chinese, for symbol manipulation "is not by itself enough to guarantee cognition, perception, understanding, thinking and so forth" (p. 26).

What, then, is required for these cognitive capacities? There are specific causal powers of the brain that produce them, causal powers that computers do not have, Searle says. It is not that there is something funny going on in the pineal gland, as Descartes thought, but that "brains are specific biological organs, and their specific biochemical properties enable them to cause consciousness and other sorts of mental phenomena" (p. 29). Searle maintains that it is the neurochemistry that somehow can give meaning to the otherwise meaningless syntax, the neurochemistry that permits the semantic interpretation,

a neurochemistry that computers do not have. If silicon chips were to be able to do it, Searle says, it would be because "the chemistry of the silicon chips is capable of duplicating the specific causal powers of neurons to cause consciousness."[5] But present-day computers, lacking the specific biochemical properties of the brain, are confined to blind syntactical manipulation, which does not support understanding. Exit artificial intelligence from the discourse on understanding, according to Searle, since computers do not understand.

Why is Searle so sanguine about this mysterious causal power of human brains? (It sounds so Cartesian.) Obviously, if you do not have a brain, you cannot understand Chinese. Obviously brains have the "right stuff," and some future machine that might duplicate the brain's causal powers, whatever they may be, *will* understand Chinese, *will* be able to interpret semantically meaningless syntax. Such causal powers are just plain biology for Searle.

> Consciousness, in short, is a biological feature of human and certain animal brains. It is caused by neurobiological processes and is as much a part of the natural biological order as any other biological features such as photosynthesis, digestion, or mitosis. (Searle, 1992, p. 90, italics deleted)

But it does not necessarily follow, even accepting that brains "are capable of causing and sustaining consciousness" (p. 93), that brains semantically interpret neural syntax so that reference is made to an outer world; perhaps something very different is going on in the brain that does not entail bridging an inner syntax/outer world duality by semantic interpretation.

In any case, the computer is no better off than Searle in the Chinese Room when it comes to understanding Chinese. Note that Searle is not anti-machine in principle; it is just that computers will not do, lacking the right biochemistry.

Churchland and Churchland (1990) argue against Searle that syntax by itself is constitutive of and sufficient for semantics; it is just that we do not know enough about how the brain actually works to see that syntax alone carries semantic distinctions. Once we know how the brain does it, they argue, we can make a machine do it. "...if one can just set in motion an appropriately structured internal dance of syntactic elements, *appropriately connected to inputs and outputs*, it can produce the same cognitive states and achievements found in human beings" (p. 34, italics added). Note the handwaving over brain operations: Brain syntax is *de facto* semantic, and some day bench researchers will show how it works.

Although it is not apparent from the polemic going on, the Searle and Churchland camps are not that far apart. Searle waves his philosophical hands at brain chemistry, whereas Churchland and Churchland, as neurophilosophers, point to "appropriately connected" neural network configurations of the brain.

The only difference is that Searle thinks syntax is somehow imbued with meaning, whereas Churchland and Churchland think that syntax does not need supplementation but that a rich enough syntax will be sufficient. In brief, Churchland and Churchland completely assimilate semantics to syntax,[6] whereas Searle keeps them distinct but related; nevertheless all agree that the assimilation or relationship, however it turns out, depends on brain properties. This polemic turns out to be over not so much after all, which only heightens our deconstructive suspicions that some metaphysical commitment is being swept under the philosopher's rug.

2. The semantic relation between syntax and world

It is imperative in deconstructing the Chinese Room to remain clear about the relationships among syntax, semantics, and the perceptible world to which the syntactical patterns refer when semantically interpreted. It is the semantic capacity that connects syntax and world. "Syntax," "semantics" and "world" must be clarified for the Chinese Room discussion to be evaluated.

We have seen that the Chinese squiggles and squoggles are purely syntactic for Searle, who does not understand Chinese writing. Syntax is a meaningless pattern, just squiggly marks on slips of paper handed in and out of the Chinese Room, insofar as Searle is concerned. But since the brain plays so prominent a role in the debate, we should properly focus on *brain writing*, i.e., a syntax consisting of electrochemical patterns, of neural squiggles and squoggles, so to speak. The Chinese writing, after all, is written into Searle's brain during the gedanken experiment, and this aspect cannot be ignored.

This shift of attention to brain writing has a decisive impact on the Chinese Room debate. For the marks to be *seen* by Searle (which, after all, is what launches his story), they must be encoded as brain syntax. The semantic connection between Chinese squiggle/squoggles and the world gives way to the semantic connection between Searle's neural squiggle/squoggles and the world.

What is going on inside the Chinese Room is that Chinese writing is mapped into Searle's brain writing. More carefully put, the Chinese graphics are subjected to sensory processing, and the resulting "record" of sensory analysis is encoded as neural syntax. Outside Searle's brain is the everyday perceptible world, which for Searle looks like the inside of the Chinese Room.

Now brain writing of the sensory record is syntactic, purely meaningless neural squiggles and squoggles. How does Searle's neural syntax relate to a world that includes marks on paper that *look like* squiggles and squoggles to those of us who do not understand Chinese? Just *how* does the semantic relation bridge the ontological duality between meaningless formal-syntactic squiggle/squoggles and the meaningful world? Searle agrees with Churchland

and Churchland that the brain does it, the biochemically-based brain appropriately connected to its inputs and outputs. So let us consider whether the properly connected "doubly-embedded" brain—the brain embedded in a behaving body in turn embedded in a world niche—can account for the semantic relation.

3. The brain basis of semantics

Psychology provides two main stories of the semantic relationship between syntax and world, but first let us consider two long repudiated stories.[7] There is a classical view that a *copy* of the world is impressed on the brain at the sensory receptor-transducers, and the perceptible world is somehow constructed from the copy. Thus we are directly acquainted with a world representation, not the world as such, which can only be inferred from the representation.

Gibson was able to rule out this classical story on purely psychophysical grounds: there is typically no constant world available in the input flux for copying, yet there is a constancy to world objects.[8] For example, walking around a rectangular table we see it as rectangular the whole time, even though there is never a rectangular image impressed on the brain at the retina, only a changing flow of trapezoids. Thus the theory that the brain's representation resembles the world in virtue of being based on a copy of the world does not hold up to empirical investigation.

Another classical view, which goes back to Plato, has the world constructed not from literal copies, but from sensory scraps and/or from some initially homogenous but differentiable raw material (*hyle*). Plato's *Demiurge*, the god who shapes chaos into cosmos, is modeled on the potter molding the clay in accordance with his Idea of the pot. (*Demiurgous* literally means "craftsman.") The world is not outside the brain but is somehow *synthesized* inside the brain. Here the inside brain/outside world duality is reduced to a (seemingly more manageable) inside/inside problem. Now the problem is the relation of syntax inside the brain to the perceptible world synthesized inside the brain. The issue here, of course, is the Cartesian ghost in the machine that, Demiurge-like, does the synthesizing.[9] Even if it is said that the results of sensory analysis provides instruction, i.e., gives the rules of synthesis, the actual synthetic process, remains a complete mystery. Note that it is not possible to make an analogy to worlds produced by computer graphics.[10] The computed world leans on the semantic capabilities of the programmer, which are left quite unaccounted for in the classical story of world synthesis.

Of course, both of these repudiated classical views are horrific, since in them the world perceived is some kind of constructed world inside the brain.

The "real world" is sadly unknowable in any immediate way, *noumenal*, for the perceptible world is entirely produced from copies or scraps or amorphous material. In these classical theories we cannot even properly say that the world produced by the brain is a *model* of the actual world, since the world produced is the only world there is for each and every one of us; there is nothing else which can properly be called "world." This "reduces" the inside/outside problem to an inside/inside problem, but at the price of each brain being a kind of monadological bubble of perception floating through a dark energy sea that is knowable only in its abstract mathematical structure. (Compare this image to the mood of Heidegger's "clearing" [*Lichtung*] surrounded by dark "Earth." Only Castaneda's "sorcerer" could love such a grimly isolated human situation!) It is, in fact, these horrific classical views that the metaphysical tradition, in its modernity, decries as "metaphysics," while continuing to feel pristine. My version of contemporary postmodernism is to some extent reminiscent of the the classical tradition, as we shall see, but stripped of its dualisms.

So much for repudiated accounts of the semantic relation. Of the two main contemporary views, Gibson's is the less prominent one. What has been called here the "semantic relation" between meaningless syntax and meaningful world is for Gibson accomplished by "information pickup." With respect to the example of walking around the rectangular-looking table, Gibson points out that even though there is a succession of trapezoidal images on the retina, there are invariant abstract relationships across that succession which specify rectangularity. That is, if ten pictures of the retinal image were taken as we walk around the rectangular table, each trapezoid would look different, yet certain relationships having to do with the trapezoids' angles and the proportions of the sides would be conserved over all the trapezoids. (Similarly, as we watch a flock of birds wheel over the meadow, their formation continually changes, and yet something remains the same, invariant, in the relationships among members of the flock.) To pick up this invariant abstract information available within the input flux is, according to Gibson, to perceive a table that continues to look rectangular. Thus the semantic relation between syntax and world is accomplished by information pickup, notably of invariants in the input flux.

The key problem with Gibson's story for present purposes is that *abstract information is purely syntactic.*[11*] Invariants are ab-stracted from—literally, lifted out of—the domain of the concrete world; there is nothing perceptible about them. So Gibson has no account of the inside syntax/outside world semantic relationship, since Gibsonian abstract information pickup is purely syntactic.

This can be illustrated with another Gibsonian example of perceptual constancy.[12] Why is it that when we look at a string of telephone poles receding in the distance, they all appear to be the same height, even though the retinal

image of the poles gets smaller and smaller for the more distant poles? Gibson points out that the line of the horizon cuts each telephone pole into an upper and lower segment. The *ratio* of upper to lower segments is constant, even though the *sum* of the segments decreases with distance, and it is the invariant ratio that determines the perception of constant size. But an invariant ratio is something abstract—.65, say—and perceived size is concrete. The telephone poles *look* the same size, but the information picked up is the invariant number .65. How does the pickup of *abstract* information provide us with the way the world *concretely* looks? There is something essential missing from Gibson's story.

By far the mainstream solution to the semantic relationship between brain writing and world is that the brain generates an abstract specification of what is in the world. These specifications are variously called "schemata,"[13] "perceptual hypotheses,"[14] "constructs,"[15] and in the philosophical literature, *noemata*,[16] "intentional content,"[17] "propositional attitudes,"[18] and "hypothesis generation."[19] The record of sensory processing is matched against the perceptual hypotheses which may or may not be confirmed. That is, the perceptual hypotheses have conditions of satisfaction that the records of sensory processing variously meet. Perception is thus hypothesis confirmation, fulfillment of schemata. "Perception is where cognition and reality meet," says Neisser[20], that is, perception arises out of the match between schema (hypothesis) and input. Thus I see a rectangular table when my hypothesis concerning a rectangular table is confirmed by certain invariants in the input flux.

But note carefully: *the brain's information as a result of the matching process is the extent to which its conditions have been satisfied.* All the brain has to work with are (l) the neural squiggles and squoggles that record the abstract result of its sensory processing, and (2) the status of its abstract conditions, satisfied or not. All of this is formal-syntactic and in no way explains the semantic relation between syntax and world.

Fodor calls this conclusion "methodological solipsism."[21] This is tantamount to the idea that we are "windowless monads" who cannot see outside but know only whether or not our hypotheses are confirmed, while isolated from whatever it is that confirms the hypotheses. A typical way of avoiding this conclusion is to assimilate perception to the broader category of cognition. The perceptible world can then be ignored while shifting focus to the act of recognition. But recognition is just hypothesis confirmation, and so the solipsism problem is never confronted.

We can see this problem vividly in the Nobel Prize winning, feature detection studies of Hubel and Wiesel.[22] Move a line at a certain orientation through the cat's visual field, and a certain neuron increases its firing rate. The neuron "detects" the line, it is said. But insofar as the cat's brain is concerned,

what actually happens is that the neuron's conditions of satisfaction are fulfilled and it fires more rapidly. What it is *in the world* that satisfies the neuron's "hypothesis"—*this* knowledge is contributed by the semantic capabilities of Hubel and Wiesel, who perceive the line and its correlation with the neuron's firing. All the brain knows is whether or not its abstract conditions have been satisfied. And when we turn to study Hubel and Wiesel's brains, with *their* feature detectors, the identical problem recurs, requiring an external observer to supply the semantic interpretation.

I conclude that we have no scientific explanation of the semantic relation between meaningless syntax and meaningful world. Whatever the dispute between Searle and the Churchlands, there is complicity among them in solving the semantic issue: the relation between brain writing (inscribed as meaningless neural squiggles and squoggles) and perceptible world. The solution is left to empirical science, to some future account of the brain "appropriately connected to inputs and outputs." But when we carefully look at the doubly-embedded brain so connected up, we find not explanation but the typically modernistic *faith* in the progress of science. Or, as we shall later see, no explanation can be found—without paying the price.[23*]

4. Churchland and Churchland's connectionism

Now Churchland and Churchland try to evade Searle's conclusions by saying that Searle's argument applies only to computers, and not to neural networks of the brain. It is important to note here that the term 'neural networks' is typically used ambiguously, sometimes referring to the silicon variety and at other times referring to networks in the living brain. But this is not generally considered a problem, since it is assumed that silicon nets are but a simplified version of living nets. We shall see in chapter four that this assumption is pernicious, but for now 'neural networks' will be conventionally used, without always pointing out whether the silicon or living realization is meant, since conventionally they imply each other.

In the ten years intervening since Searle first introduced the Chinese Room, there has been a great upsurge of work on connectionist models of brain functioning. Churchland and Churchland think that replacement of symbol manipulation computer-like devices that Searle originally critiqued with connectionist machines hold great promise.

> When brains are said to be computers, it should not be implied that they are serial, digital computers, that they are programmed, that they exhibit the distinction between hardware and software or that they must be symbol manipulators or rule followers. Brains are computers in a

> radically different style. (Churchland and Churchland, 1990, p. 37)

Just how the brain manages meaning is "still unknown" (p. 37). "Exactly" which "causal powers" are relevant remains to be determined (p. 37).

> To develop a theory of meaning more must be known about how neurons code and transform sensory signals, about the neural basis of memory, learning and emotion and about the interaction of these capacities and the motor system. (Churchland and Churchland, 1990, p. 37)

Their theory of meaning thus depends on future empirical findings with respect to brain syntax, as we have seen. They are hopeful that parallel processing neural nets will do the trick. (In parallel processing, multiple operations take place at the same time, whereas in the serial processing that characterizes traditional computers, operations take place sequentially.) But then they play right into Searle's hands by conceiving of neural networks as performing computations.

A silicon neural network with its connection weights properly adjusted "computes almost any function—that is, any vector-to-vector transformation—that one might desire" (p. 36). Again, the neural network is "a device for computing a specific function."[24] Searle responds that if it is a computation that is going on, this means that serial and parallel processing are *both* syntactic, since formal computation is purely syntactic.

> The parallel, "brainlike" character of the processing, however, is irrelevant to the purely computational aspects of the process. Any function that can be computed on a parallel machine can also be computed on a serial machine.... You can't get semantically loaded thought contents from formal computations [syntax] alone, whether they are done in serial or in parallel. (Searle, 1990, p. 28, brackets added)

So Churchland and Churchland's appeal to neural nets with properly connected input/output functions cannot be sustained. The nets are computing, and no matter how much is learned about the workings of the computation, connectionist syntax is still inside the brain and a semantic interpretation is needed to connect with the outside world; that is, the brain needs somehow to derive the perceptual world from meaningless squiggles and squoggles.

Churchland and Churchland insist that neural nets *compute* input-output functions, but it is not clear that a computation is going on. One problem for connectionism as computational is that there is widespread fanning in on and fanning out from each neuronal node in the net so that local events open quickly to the whole. Because of this rich interconnectivity, the network's operation is

holistic, and this holism is incompatible with the idea of computation. The serial rearranging of strings of localized exact atomic symbols in a logical transformational analysis is fundamentally different from a holistic process. Just because it is possible to *simulate* (at least approximately) holistic nets on symbolic computational devises—and note that this is most slowly and cumbersomely realized—accomplishing a simulation does not necessarily mean that what the neural nets are actually doing is computing. Similar results can be obtained from dissimilar processes. Perhaps computation is just an obsession of modernity (although its roots lie in the Greek *logos*).

Furthermore, we must keep in mind Chomsky's sharp distinction between "competence" and "performance." With respect to language, linguistic competence is provided by the grammatical rules that generate the complete corpus of whatever *might* be legally said, whereas performance has to do with what is *actually* said, i.e., the creative use of human language spontaneously undertaken by individual speakers. Chomsky's theory of language is explicitly restricted to competence.

> The study of grammar raises problems that we have some hope of solving; the creative use of language is a mystery that eludes our intellectual grasp. (Chomsky, 1980, p. 222)

Similarly for all human acts, our competence is something formal, described by abstract computational rules, whereas the individual human act spontaneously undertaken is something else again. For example, a bicycle rider's competence may be given by the rule "wind along a series of curves, the curvature of which is inversely proportional to the square of the velocity," but no one riding a bicycle actually follows such a rule, nor was the rider ever even taught such a rule.[25] So just because Churchland and Churchland's neural net transforms an input vector to an output vector this does not necessarily imply that a computation is being performed. Although our abstract capacities might be computationally described, like the bicyclist, our actual performance is "a mystery that eludes our intellectual grasp."

What might neural nets be doing, then, if not computing? Is there an alternative to the information processing of modernity? Let us try out a different version of Churchland and Churchland's connectionist gambit, and look to neural nets for an account of the semantic relation.

5. What neural nets do

What neural nets do is spontaneously find and spontaneously avoid certain states in their repertoire of possible states. States that the networks tend to move away from are called "repellers" and states into which the networks

"settle" or "relax" are called "attractors." No information is being processed in such an evolution of states. This spontaneous process is stochastic: attractors are associated with a certain probability that the net will settle there, but the settling process is unpredictable.

It is of fundamental importance that this spontaneous stochastic movement toward attractors is *not rule governed.*[26] Connectionist machine operations (i.e., performance) do not follow rules (even though the machine's competence can be so described). There is no program (in either silicon or living realizations) that determines which state the net will likely settle into; this is quite unlike the case for computers, which are heavy with necessity, permitting no exceptions. Instead the net spontaneously *self-organizes* toward attractor states, and under certain conditions, may even enter states never before achieved. Neural nets are light with possibility.

What characterizes states that are attractors? We must see first that the self-organizing process operates under multiple constraints. Of crucial importance, there are weights on the excitatory and inhibitory connections between nodes. These weights control how much influence gets through the connection and thereby constrains the self-organizing process. Presumably some connections weights are fixed, given by the genes; some weights can be modified through learning; and yet other weights fluctuate from moment to moment, i.e., are "tunable" (Globus, 1989a). The record of sensory analysis as input to the network puts an activation pattern on the network which acts as an external constraint on self-organization. Memory traces are more-or-less permanently encoded in the connection weights; memory traces function as externally derived constraints due to learning. The tuning of weights, in contrast, leaves no trace and provides an internal constraint on self-organization. (This imperfect analogy may be helpful: The road system is a trace of construction activity that constrains where we might drive, whereas the driver turning the wheel, which also constrains where we might drive, leaves no trace but fluidly changes.)

The self-organizing process finds a good enough compromise across the various constraints, similar to an effective political process that achieves a mutually beneficial consensus among the various constraining special interests, so that everyone gets a piece of the pie. *Attractors are thus states of the network that optimize multiple constraint satisfaction.*

Neural nets, then, spontaneously find states of relative harmony between conflicting constraints in an unpredictably self-organizing fashion. That there will be *a* state of good enough consensus is predictable, but *which* state is unpredictable. Their competence—what the nets are capable of computing—is describable in logical terms as input/output mathematical functions, but their actual performance—what the nets produce at time t—is not rule-governed and depends on the whole. If neural nets are not performing computations but are

doing something else, then this may open up a solution for the problematic semantic relation between syntax and world, which has preoccupied the present deconstruction.

6. From beings to being

A fruitful question to ask here—a question that leads us away from metaphysics but at a terrible price—is this: *What is it to BE the doubly-embedded connectionist brain settled into a particular state*? Or, put less statically, since the input flux flowingly changes and there is also flowing change of the network tuning, **what is it to BE the doubly-embedded brain unpredictably self-organizing along its flowing path of states**? The focus here is not on what functions the brain computes—its competence—but on *being* the doubly-embedded brain in its self-organizing, flowing performance. The question thus leads from the metaphysical preoccupation with objective entities (*Seienden*) to Being (*Sein*), to lived existence (*Dasein*) which has been "forgotten" in the objective focus. I believe the right answer to the issue of "being the brain" is this: **to BE the doubly-embedded brain is to find oneself thrown "in" a world** (Globus, 1989c). The "in" here is not like putting noodles "in" the soup or finding a beetle in a box but has the Heideggerian sense of "being in," which Dreyfus (1991) has elucidated. This is the sense of "dwelling in," "involvement with," "being amidst" the world, always already "occupied" with the world. These are the meanings of the Heideggerian expression 'being-in-the-world'.

The relationship between the record of sensory processing and perceptual hypothesis is unproblematic here: both are constraints on a self-organizing system. The flock of birds is a self-organizing system that must deal with interferences in the flight path, such as trees and telephone poles that constrain their flight, while maintaining an invariant integrity in the flock's formation. Analogously, the flow of the neural networks is constrained by sensory results, learning and perceptual hypotheses. This process does not confirm a hypothesis by recording a match but instead finds harmony across constraints. The inside/inside problem (to which the outside/inside problem has been transformed) is thus resolved by self-consistent settlement.

Syntax as a purely physical configuration without inherent meaning *is a constraint*. Sensory syntax results from sensory processing of input such that a pattern of excitation is imposed on the net, constraining it. The conventional notion of sensory syntax as a representation is swept away and replaced by the notion of syntactical constraint.

Conventional notions of the semantic are also replaced. If we look back to Husserl's formulation, semantic interpretation is the process of "ensouling"

(*beseelen*) the meaningless "hyletic data" in the noetic act. Searle's view that brain chemistry somehow imbues syntax with meaning is tantamount to Husserl within a neural framework. Churchland and Churchland's more contemporary idea, as we have seen, is that semantic distinctions are somehow really syntactic distinctions. I propose a very different account of the semantic.

The distinction was made above between relatively permanent changes in the connection weights due to learning and moment to moment "tuning" of the weights that leaves no trace. (The highly important concept of "tuning" will be broadened in later chapters.) Permanent and tunable constraints are equally weights on the connections. Because of tuning, the net has a continually changing attunement that constrains its evolution. The semantic is not something added to syntax nor a kind of syntax but is a function of the network's attunement, which constrains the flow of network states. *Both the syntactical and the semantical are properly considered to be constraints on a self-organizing process.*

So we have a dynamical process in which the meaningful world is a settlement. *The semantic relation is in effect dynamical*: a spontaneous, probabilistic, self-organizing process under constraint. Our world thrownness *is* the flowing dynamical state of the network that settles out; to *be* that dynamical network state is always to find oneself already thrown in a meaningful world.

The semantic relation can thus be explained by taking neural net *performance* (not competence) to be non-computational. The "world" is "inside" (as in the repudiated classical views, to borrow temporarily a metaphysical term). The world settles out of an unpredictable self-organizing process constrained by the records of sensory analysis, by learning, and by the attunement due to cognitive tuning of connection weights. The price of this move is that the traditional fundamental duality between the inside of the brain associated with subjectivity and immanence, and the outside objectified world, becomes a metaphysical illusion. Inside and outside are both derived, secondary, hoisted by a flowing, self-organizing, holistic settling process which gives our world thrownness. On the traditional view, the world of things has a status of separate existence that becomes comprehensible as we contemplate it. My claim here is that to be the doubly-embedded brain in its ever-shifting state of settlement is always already to find oneself in-the-world.

As much as our metaphysical entanglements force us to think of the world as "outside," deconstruction of the Chinese Room reminds us that outside/inside is a derived duality provided by a more primary dynamical process. In other words, our consciousness of the world, indeed the whole subject/object orientation that dominates our thinking, is given by a spontaneous dynamic. If so, there can be no avoiding the anxiety of being separated, windowless, monadic beings in an undisclosed surround, beings in each of which separate but coherent worlds light up in parallel, through

self-organizing processes. To the extent that the constraints are comparable across monadic entities, the world settlement is comparable, which serves to mitigate somewhat our stark existential isolation.

7. Discussion

We have seen that the Chinese Room controversy effaces a metaphysical complicity in which the semantic relation between syntax and world is to be accounted for by an empirical story of the brain appropriately connected to its surround. This is surely "neurophilosophical" in that the philosophical argument relies on science.[27] We saw, however, that current theories in psychology fail to account for the semantic relation. In the Gibsonian story, the brain picks up abstract information about the world rather than the concrete perceptible world, such as Chinese marks on the page that look like squiggles and squoggles to many. In the mainstream story, there is a sensory syntax (the record of sensory analysis), an abstract specification (*qua* conditions of satisfaction), and the status of the various conditions of satisfaction (the match). Psychology is left "methodologically solipsistic" here, as Fodor says, without semantic relation to the world.[28] So those engaged in the Chinese Room controversy can only hope to be rescued by empirical science in some presently inconceivable way. This unhappy outcome motivates the present wrenching of the metaphysical viewpoint, the *Sprung* or leap from computational beings to Being.

The metaphysical tradition always *objectifies*, as has been emphasized. The brain is a kind of system—a wet one rather than one made of silicon. What it is to *be* the (doubly-embedded) brain system is not brought up because of the objectification. This wrench was undertaken in the wake of deconstructing the Chinese Room. To be the doubly-embedded brain is to find oneself always already thrown in a world. Conceiving of the brain as connectionistic: the flowing records of sensory analysis (activation patterns), the records of learnings (adjusted connection weights), and the intentional tuning of connection weights—all these constrain a self-organizing process that settles into a state which is our world thrownness. In this model, sensory syntax is a constraint, the semantic also turns out to be a constraint (attunement), the semantic relation turns out surprisingly to be a dynamical self-organizing process, and the world with us "in" it (*bei* it) is a settlement.

This model thus leaves the human condition decidedly monadic—and very odd in so far as everyday common sense and the metaphysical dualistic tradition is concerned. It is this outcome that metaphysics desperately wants to avoid, a symptom of which is the long, unresolved commotion over the Chinese Room in which the problematic semantic relation between syntax and world is effaced. Our true situation, I suggest, is this: Each of us constitutes our own

world. Our worlds are coherent to the extent that constraints are shared—culturally, linguistically, developmentally, and so on. Our metaphysical entanglement with the common world—the everyday one in which it seems that we might reach out and touch each other—ensnares us in delusion, *maya*, as the transpersonal tradition has long taught.

This outcome should be distinguished from idealism, which is also caught up in a kind of metaphysics. What is primary is not subject (as it is in idealism) or object (as in materialism) but a dynamical process in which subject/object and all the other metaphysical dualities are derived. This deconstructs the last bastion of metaphysics which even Heidegger and Derrida retain: the conviction that the perceptible world is external to us, as it seems both to everyday commonsense and science. Since this illusion is unavoidable, we might just as well take it as it appears, or perhaps, "we are meant" to live in *maya* anyway, so why fuss? In our more reflective moments, however, we can labor at deconstructing metaphysics for a time and, in so doing, transiently appreciate the astonishing monadic plight that is our human condition.[29*]

APPENDIX A

DENNETT, THE ILLUSIONIST

Dan Dennett's *Consciousness Explained* has some great accolades in the margins of the flyleaf. Douglas Hofstadter (*Gödel, Escher, Bach*) says,

> Daniel Dennett's *Consciousness Explained* is a masterful tapestry of deep insights into this eternal philosophical riddle...Dennett has written a profound and important book...*Consciousness Explained* represents philosophy at its best...I believe it will long be remembered as a major step along the way to unraveling its [consciousness'] mystery.

Consciousness is not the primary concern of the present work, which is formulated more existentially, but it is of interest to assess Dennett's mainstream explanation of the semantic relation in terms of hypothesis generation and confirmation. This explanation is given in what Dennett calls the "Prelude" to his book. Of course, if the Prelude sets up an illusion—the magic, as usual, taking place before the official start of the performance—then Dennett's entire enterprise of explaining consciousness is undermined.

Dennett gives this summarizing statement,

> The general idea of these theories is that after a certain amount of "preprocessing" has occurred in the early or peripheral layers of the perceptual system, the tasks of perception are completed—objects are identified, recognized, categorized—by generate-and-test cycles. In such a cycle, one's current expectations and interests shape hypotheses for one's perceptual systems to confirm or disconfirm, and a rapid sequence of such hypothesis generations and confirmations produces the ultimate product, the ongoing, updated "model" of the world of the perceiver. (Dennett, 1991, p. 12)

The semantic relation is thus provided by confirmed perceptual hypotheses. Now the deconstructive eye is caught by the peculiar language in the Prelude to *Consciousness Explained*. Here is a list of related words, with their frequency of occurrence in the 16 pages of the Prelude:

illusionist, illusion (18)
dupe (8)
evil scientists (6)
victim (6)

evil demon, demon (5)
trick, trickery (4)
prankster, prank (2)
gullible (1)
magician (1)
clever devil (1)
cunning (1)
sneaking (1)
villain (1)

This striking and repeated language, which Dennett is using to dispel certain myths, raises the deconstructive suspicion that Dennett himself may be an illusionist. Dennett even warns us about his "intuition pumps," which are colorful and impossible experiments in thought only:

> ...let the reader beware: My intuition pumps, like anyone else's, are not the straightforward demonstration they seem to be; they are more art than science. (p.440)

Indeed, Dennett makes something out of nothing in the Prelude to what he is going to write.

Now hallucination and dreams create a problem for the standard theory of perception that Dennett espouses. For that perceptual theory, the hypotheses that are generated are confirmed or disconfirmed by information provided by the senses. But during dreaming, sensory input is markedly attenuated, and in hallucination, the sensory input does not confirm the hypothesis. Thus Dennett has to argue away dreams and hallucination to get his account of perception, which is integral to any theory of consciousness, off the ground.

Here is how he does it:

> All we need suppose must happen for an otherwise normal perceptual system to be thrown in a hallucinatory mode is for the hypothesis-generation side of the cycle (the expectations-driven side) to operate normally, while the data-driven side of the cycle (the confirmation side) goes in a disorder or random or arbitrary round of confirmation and disconfirmation... (p. 12)

So the generation of perceptual hypotheses is working fine, but the data is random. How, then, does confirmation ever occur, if the data is disordered or random or arbitrary?

> ...noise in the data channel is arbitrarily amplified into "confirmations" and "disconfirmations"... (p. 12)

> ...a bit of noise in the system gets mistakenly amplified into a YES... (p. 13)

This is *creation ex nihilo* for sure; when you amplify noise, you get more noise, not something approaching a lullaby.

To drive this point home, let's consider one of Dennett's examples.

> Why, for instance, does the hunter on the last day of deer season see a deer, complete with antlers and white tail, while looking at a black cow or another hunter in an orange jacket? Because his internal questioner is obsessively asking: "Is it a deer?" and getting NO for an answer until finally a bit of noise in the system gets mistakenly amplified into a YES, with catastrophic results. (p. 13)

But the data of a black cow or another hunter is not anything approaching disorder; these are highly organized data bearing some similarity to deer. A cow, after all, is a 4-legged animal like a deer, and even a hunter looks more like a deer than does arbitrary data.

Amplification of noise is not going to confirm hypotheses, so Dennett's standard theory of perception as perceptual hypothesis confirmation still has the classical philosophical problems of dreams and hallucinations to deal with. If perception is just hypothesis confirmation by sensory data, how then do we perceive things that aren't really there when dreaming and hallucinating? Dennett's answer relies on an illusion in which something is gotten from nothing—hypothesis confirmation from randomness—and this will not do.

APPENDIX B

NETWORK AND BACKGROUND IN SEARLE'S THEORY OF INTENTIONALITY

The preceding discussion of the Chinese Room criticizes only one aspect of Searle's theory of intentionality. Other aspects of that theory are consistent with the neural net model proposed above. This appendix mitigates the critique by mapping Searle's concepts of Network and Background into neural net terms.

Searle (1983) distinguished between a Network of "intentional phenomena such as meanings, understandings, interpretations, beliefs, desires and experiences" (1992, p. 175) and a Background necessary for the Network's functioning. Intentional states have conditions of satisfaction.

> Each state itself determines under what conditions it is true (if, say, it is a belief) or under what conditions it is fulfilled (if, say, it is a desire) and under what conditions it is carried out (if it is an intention). In each case the mental state represents its own conditions of satisfaction. (Searle, 1984, p. 60)

Intentional states are "relative to a set of capacities that are not themselves intentional" (1992, p.175). This Background of nonintentional capacities makes intentional phenomena possible.

Intentional phenomena are organized into a Network of associated intentional phenomena.

> To have one belief or desire, I have to have a whole Network of other beliefs and desires. Thus, for example, if I now want to eat a good meal at a local restaurant, I have to have a large number of other beliefs and desires, such as the beliefs that there are restaurants in the vicinity, restaurants are the sort of establishment where meals are served, meals are the sort of thing that can be bought and eaten inside restaurants at certain times of day for certain amounts of money, and so—more or less indefinitely—on. (p. 176)

The intentional desire to eat a good meal in a local restaurant might be implemented "in any indefinite number of different and inconsistent ways" (p. 176). Searle asks, "What exactly constitutes eating, what constitutes a meal, what constitutes a restaurant?" (p. 176). The Background of practises—the way one uses knowledge and does things around here—fixes the way the intentional content is satisfied.[30*]

Searle (1983) distinguishes the Network from the Background (while emphasizing the relativity of Network to Background), whereas Searle (1992) decides that the Network is part of the Background because it is difficult to distinguish Network from Background. "How about the belief that George Bush wears underwear or that he has two ears?" Is that intentional or nonintentional?

But once the Network of unconscious intentional phenomena is merged with the Background, we have to stretch one roof over two disparate kinds. The intentional has conditions of satisfaction, but practises don't specify—they are skills, applications—yet both are supposed to be part of the Background. The intentional part of the Background can become conscious, but the practises remain unconscious. Searle (1992) is left with a strain in his concept of the Background, where the Network remains somehow indigestible.

The strain can be relieved, however, if we locate Background and intentional Network in the neural net model. Intentionality maps to tuning. Corresponding to the intentional act's conditions of satisfaction is the network attunement; more carefully put, the conditions of satisfaction contribute to the attunement, which is something greater, expressing the relevant Network. If I now want to eat a meal at a local restaurant, I have to believe that there are restaurants in the vicinity, that meals are served at restaurants, and so on. The full network of beliefs and desires around wanting to eat a meal at a local restaurant maps to network attunement. Thus I am attuned for eating a meal at a local restaurant, when I desire to do so.

Background practises, on the other hand, map to learned adjustments of connection weights. Through experience, these weights are adjusted and the network gains knowledge and skill in self-organizing to optimal solutions for the problems posed by input. (By "knowledge" I mean what we know around here, e.g., that adult executives wear underwear, and by "skill" I mean how we go about things around here, e.g., that we give an order to the waiter to get a meal.) We don't have to tune for presidents wearing underwear or having two ears because that is already built into the connection weights by learning. But we *may* tune for presidential candidates having two ears, as we tend to do for Perot, whose two large ears have been so emphasized by political cartoonists. There is nothing mutually exclusive about intentional tuning and practises encoded in connection weights—functionally they are both constraints—but the mechanisms are entirely different. So Network and Background are distinguished by mechanism but not by function, which encompasses both Searle's earlier and later accounts of intentionality.

CHAPTER THREE

THE CONTINENTAL TRADITION AND COGNITIVE SCIENCE

One prominent twentieth century strand of postmodern expression in discourse has flourished in the work of Martin Heidegger and Jacques Derrida. This must immediately be said: It is impossible to love Heidegger, but Derrida is something else again—playful, complicating, ever open, fluid, elusive. It is a very deep puzzle for the psychiatrist that a man like Heidegger, who was an anti-Semitic Nazi, should have a profound insight into human existence. It is generally held that Heidegger's political aberration evidences a fundamental flaw in his philosophy.[1] However, focussing narrowly on Heidegger's philosophy blinds us to his awesome deficiencies as a human being. It is quite possible to be a great philosopher and, say, have a Narcissistic Personality Disorder in which the self is greatly loved and the other easily denigrated and dismissed. Surely this is a topic as important as the relationship between Heidegger's philosophy and his Nazism. Heidegger's philosophical genius combined with his abominable values sharply underlines the question: What is it about us that can come out so bad, or so good, for that matter?

It has been *verboten* in philosophical circles to talk about Heidegger's personality, but the emperor has no clothes: There must have been something radically wrong with Heidegger as a person, apart from his philosophical orientation. Now, I don't know if Heidegger, indeed, had a bona fide Narcissistic Personality Disorder or not. If a psychiatry resident came to me presenting a case like Heidegger (see especially the chapter on Heidegger in Young-Bruehl's biography of Hannah Arendt for clinical material), then I would allow, in my professorial clinical judgment, the tentative psychiatric diagnosis of Narcissistic Personality Disorder. Some other case of narcissism would do to make my point, but Heidegger's case is especially apropos because of the startling discrepancy between his philosophical insights and his person. Just as we comprehend the functionality and equipmentality of the tool *when it breaks* (a favorite example of Heidegger's), we can see that meaning constitutes the world in light of Heidegger's deficiency. Our meanings are what makes us turn out so bad, or so good, for that matter.

The world we take for granted—this pragmatic *Umwelt*, the world surrounding us, in which I type on a computer and you read a text—depends

crucially on a world of meanings. In the intentional act, a world is produced, or better, allowed to presence, with its taken-for-granted quality. Suppose a person's actions are "narcissistic"—for genetic, and/or physiological, and/or developmental, and/or cultural reasons, whatever. Then the world of Narcissus presences, in which the Self and its wants loom large while the other is diminished, except as a threat to the Self. The other waxes and wanes with the Self. Here the brain's attunement is narcissistic, and the world is perceived accordingly. Thus attuned, narcissistic or otherwise, whether Jew hating or humanity loving, we are always already situated in an inner world of meaning that shapes the perceptible world in which we always already find ourselves thrown. What a bitter irony that a man who deeply understood the crucial role of situatedness in clearing worlds could not break free of his own narcissistic entrapment! Heidegger himself offers vivid proof of the primacy of meaning in the constituting of worlds, no matter what profound thoughts may be concurrent.

In Part I of this chapter, I attempt to connect Heidegger to self-organizing neural nets, against his will. (It would be a facile misreading of my text to see "against his will" as my crassly reducing Being to beings.) Postmodern continental philosophy does not entirely discount the biological organism—witness Merleau-Ponty—but brain science is not deemed special among the empirical sciences. I shall disagree: Brain science has a unique sigificance for philosophy. My discussion gets very complicated after a while, in following Heidegger and the significant Turn in his thought (the *Kehre*), and we shall proceed torturously through the murk. (Lest the reader who is unfamiliar with Heidegger (or Derrida) become discouraged, take heart. Later chapters will be of a more scientific, less murky bent.) Taken as a whole, Parts I and II relate postmodern philosophy and cognitive science, allowing mutual appreciation across disciplines.

In Part II, I again attempt to connect postmodernism with neural net theory. Discussing Derrida is pivotal to my endeavor. Derrida is very interested in Freud's ideas about brain writing, up to a point. (Freud's ideas are "neurological fables" for Derrida.) But he does not seem to care about twentieth century conceptions of brain writing and has turned his attention to more literary topics. In connecting Derrida to cognitive science, I do not have as strong a sense of doing fundamental violence, as I do with Heidegger.

The discussions of Heidegger and Derrida in this chapter do not use the technique of deconstruction but are constructive attempts to link this stream of continental philosophy with cognitive science, breaching a barrier in discourse space, a barrier sustained by antagonism and disinterest between these two camps. There is a great temptation for philosophers to dismiss this endeavor as reductionistic and, therefore, unworthy of philosophical consideration. To talk of brain functioning and existence in the same breath seems to make a category

error, or at least requires convoluted philosophical discussion to be justified. But stated more carefully, it is *being* the functioning brain and existence that are spoken together, and this makes a tremendous difference. To couple existence and brain is not the same as coupling existence and being the brain.[2]

Now Nagel has made this distinction famous in asking, "What is it to be a bat?" Of course, we don't know what it is to be a bat, or a flower, or a stone, or the weather, or even each other. What is it to be the table? What is *being* the table? The question seems to make sense even though the answer can only be speculative. The question makes sense because there is something that we know what it is to be, even though we don't know what it is to be the table or the bat. As we shall see, we each do know what it is to be a particular brain embedded in a particular body embedded in a particular surround. To be this doubly-embedded brain is to exist, to find oneself thrown in a world of meanings, thrown amidst a world surround, and, for some, to find themselves *written*, productive of text. (To be some other doubly-embedded brain—say, a bat brain—is *not* to exist, in Heidegger's specific sense of *Existenz*, but to be some other way, which only bats are acquainted with.)

I. Heidegger and Connectionism: Systems that can do what *Dasein* does

To approach Heidegger from a cognitive science standpoint is wrenching. Cognitive science, in its preoccupation with computers, is very closely tied to a technology that forgets Being and to a deeply engrained western metaphysical tradition that Heidegger longs to surpass. The "computational theory of mind,"[3] which has been the mainstream perspective of cognitive science, relies on representations that reflect a Cartesian heritage severely criticized by Heidegger. A considerable "spring" (*Sprung*) is thus required to leap from Heidegger to cognitive science. This chapter is an invitation to *Mitsprung*, to leap together, in a playful spirit, with an openness to thinking "Heidegger and cognitive science," to listening for each in the other.

1. An ontico-ontological fact forgotten

Heidegger considers ontology, the science of Being, to be more fundamental than contingent ("ontic") facts (Kockelman, 1985). Furthermore, "ontology has nothing in common with any method of the other sciences, all of which as positive sciences deal with beings" (Heidegger, 1982). The crucial distinction here between the ontological and the ontic is between Beingness and something

that is. The positive sciences must be grounded in regional ontologies which are, in turn, grounded in fundamental ontology. The regional ontologies are concerned with the Being of the myriad entities that the positive sciences study—e.g., behaviors, brains, bosons—not the contingent facts about those entities that these sciences establish, while fundamental ontology is concerned with Being as such. Heidegger's focus is on Being as such, so scientific facts about specific beings (entities), although respectable, are quite irrelevant to his endeavor.

Given Heidegger's emphasis on Being, he is inevitably drawn to a unique entity for whom its own Being is an issue. That entity is, of course, the human being, which Heidegger names *Dasein*. Dasein literally means "to be *Da*." Dasein is the entity who is *Da*, "there," "present," in the sense that we ask someone awakened from sleep: Are you there? Is the world presencing to you? Are you clearing the world? Are you with it yet? Is the light on yet in your poor, foggy *Lichtung* (clearing)? It must be admitted that the referent of Dasein is difficult to grasp, since it cannot be pointed to. To be *Da* is the way that we are, to be *Da* is to be an entity that provides a clearing for Being to presence. The difficult-to-grasp signification of "to be *Da*" slowly emerges as one studies Heideggerian thought.

There is one unique fact that is forgotten within Heidegger's purview, the fact, crudely put, that *no brain, no Da-Sein*. Turn the brain to mush and the *Lichtung* goes dark, or give it increments of an anesthetic gas, and the clearing dims and finally the light goes out. Who would deny this? Or switch from the brain state known as NREM sleep to the brain state known as REM sleep, and the clearing lights up with the fantastic life-world of dreams. No future scientific revolution will change the fact's significance. Such a fact cannot be simply ignored, but must find its place in the Heideggerian scheme. The present discussion proceeds with openness toward that possibility.

Now "no brain, no Da-Sein" is a peculiar "ontico-ontological" fact, since it refers both to a being (*Seiendes*) and being (to-be-*Da*). The fact is that existence and brain are very tightly coupled, hence the connection between the ontologic and the ontic at this unique point, no one without the other. (Of course, it might be said, "No parenting, no Dasein," but the coupling is not tight here; while parent does the dishes, baby Dasein plays, whereas no brain, no play.) This is low-level science. At least in ordinary existence, existence is coupled to the body. Science has more precisely localized the entity side of the coupling in the brain, not the heart as the early Greeks thought. When there is no brain functioning at the highest cortical levels for the Dasein, there is no existence. Furthermore, when there is no ordinary human existence (e.g., when the Dasein is comatose) and we examine Dasein's brain, we do not find normal brain functioning at the highest levels.

The fact can thus be launched from either side of the coupling. "No brain, no Da-Sein; no Da-Sein, no brain" is not an ordinary fact but the critical *Fact* of an ontico-ontological coupling. Perhaps this unthematized ontico-ontological Fact will provide a way out of certain contradictions and philosophical puzzles. But first such a Fact must be lifted to unconcealment against the weight of the tradition.

Through the Fact of this ontico-ontological coupling, brain science, as the ontic science of neural functioning, enters the discussion. Since the present focus is on cognitive science, something more must be said about its relationship to brain science. Cognitive science, following the tenets of "functionalism," considers the abstract machine functions physically realized by the brain whereas brain science considers the actual neural hardware. According to functionalistic cognitive science, there is an "equivalence class" of machines, which includes the brain and the computer, and cognitive science is concerned with the abstract description of certain of those machines functions. Cognitive science, then, is connected through brain science to phenomenological ontology via the Fact "no brain, no Dasein." The topic "Heidegger and cognitive science" is thereby opened up.

Of course, cognitive science presupposes Dasein's being-in-the-world. The very praxis of science requires Dasein, for science is a human activity. No brain is cleared for scientific study without Dasein. But the dependence of cognitive science on Dasein does not mitigate the ontico-ontological Fact that Dasein is coupled to a brain machine that can be abstractly considered. This Fact must be factored into the story. Heideggerians are wont to believe that since the practise of brain science depends on Dasein, they can safely ignore brain science. My objection is that scientific praxis requires not only Dasein but an intact functioning brain too. Dasein does not have a priority over the brain in this regard.

2. Could a machine have the "right stuff?"

There is another consideration, however, that might permit a bare acknowledging of the Fact while putting it aside. Dreyfus (1979) after all has fulfilled our strong intuitions by showing that computers can't do what Dasein does. (This position is also supported by Searle's [1980] Chinese Room argument, discussed in chapter two.) Perhaps this deficiency on the part of the computer makes the machine conceptions of cognitive science ontologically irrelevant. The "no brain, no Da-Sein" issue can be put aside because something machine-like *must* be irrelevant to Dasein, or so the story goes.

Although feelings can be fierce against computers intruding into Heideggerian discourse, this neglects the possibility that the computer is just the wrong kind of machine for Dasein to couple with. There are other machines

presently discussed in the cognitive science literature that operate on radically different principles from the computer, and no one knows what the future will bring. For example, there are optical information processing machines that do not follow a linear, sequential logic. (For example, see Yevick on "Fourier logic.") Such machines are "holonomic," i.e., they follow the law of the whole (to be considered below). There are also the new connectionist machines (typically cumbersomely simulated on a computer) which are *self-organizing*. So we need to assess whether some kind of machine other than the computer might suffice.

Let's consider schematically, then, some of the general characteristics of one of these newer engines, the "constraint satisfaction machine."[4] Such a machine, I claim, counters the objection that there is no sense in exploring a connection between Heidegger and cognitive science because machines can not do, and never will do, what Dasein does anyway.

The machine to be considered is commonly called a "neural network." This can lead to some confusion as to whether the "neural net" is being considered in abstract terms, or as its neurophysiological instantiation, or as a silicon realization in a computer. These distinctions are not crucial. Since the abstract machine and its silicon implementation are always taken to be *models* of highly simplified neurophysiological networks, we can go freely back and forth, depending on context. (Because of the strongly conditioned negative connotations of "machine," I shall substitute "system" in what follows, while retaining "abstract machine" for the virtual level of discussion.)

Neural networks place constraints on self-organizing nets of richly interconnected nodes (neurons) that influence each other by excitation and inhibition. The nets spontaneously change through nodal activity to achieve satisfaction of their constraints; that is, the nets move in an unprogrammed way toward maximizing constraint satisfaction. The movement is probabilistic: there is a set of states, each with its own probability, that satisfies the constraints in a good enough fashion, and the net settles into one of them. So the system under discussion spontaneously and probabilistically self-organizes toward constraint satisfaction. Put more pragmatically, partially incompatible constraints reflect a multifaceted problem, for which the self-organizing process finds an optimum solution.

There are different types of constraints in these systems. One type is the weights on the connections between nodes. These weights determine the amount of influence that passes through the connection. Accordingly, for each node in the richly interconnected net, weights that control incoming excitatory and inhibitory influences constrain net performance. The weights can themselves be modified through learning. The system's "knowledge" (which is know-how rather than propositional knowledge) is encoded as weights on the connections between network nodes. Thus know-how is a set of constraints on

a self-organizing process, where the constraints are carried by the connection weights.

Another type of constraint is the input pattern of excitation and inhibition that disturbs the resting net in a way unique to that pattern. This pattern of input constrains the subsequent path of the net as it moves toward reconciliation of conflicting constraints. The order of the surround thus constrains the self-organizing nets. Thus, *both knowledge and environment constrain the self-organizing process, rather than a pre-set program of rules determining the path of the net.*

There is a third type of constraint—the *tuning* of connection weights—that has not been thematized in the neural network literature, primarily because of technological limitations in the simulation process. In the case of a *tunable* connection weight, the weight changes fluidly according to the play of influences upon it. The continually tuned net is accordingly in a state of fluidly changing attunement, while it is being constrained by input and learning. *Dasein's situatedness is precisely this attunement.*

Let us now explore how we might carry to the system model such intrinsically human characteristics as meaning, affect/mood and instinctual drive. This requires that there are different sources of tuning signals; a tuning system for a constraint satisfaction system is modular in organization. Each module biases the net in its particular way. The tunable weights under modular control constrain the range of possibilities. At the surface layer of the net related to perception, there is tuning for possible worlds. At intermediate layers related to thought, tuning provides the context of thought. At the output surface, there is tuning for behavioral objectives. (For example, in depressive tuning we see the world through a glass darkly, our thoughts turn gloomy, and our behaviors are tuned for failure.) Such perceptual, cognitive and behavioral attunements (as well as affective, motivational and other attunements) situate Dasein.

To summarize, the network of richly interconnected, mutually influencing nodes is under constraint due to its knowledge, its surrounding environment and its meanings, mood and motivation. Dasein's situatedness is an attunement resulting from the tuning of constraints. The net spontaneously reorganizes under holonomy to well-satisfy its constraints. The holonomy—the "law of the whole"—is due to the rich interconnectivity, so that local activity is quickly distributed over the whole. The community of nodes operates by consensus of the whole community.

This holonomy has a formal mathematical sense. There is a quantity of energy over the whole, i.e., a global energy. States in which the global energy is minimal are called, metaphorically, "attractors," and states in which the global energy is maximal are called "repellers." The net changes probabilistically to minimize the energy of the whole, settling into an attractor state. Disturbed by input, constrained and tuned, a resonant pattern is set up that proceeds to self-organize toward a harmony, a consensus, that optimizes multiple constraint

satisfaction. This system operates holonomically, finding consensus, rather than following rules as a computer does. Through the system's immense connectivity, it "lets be" constraint satisfaction, it "listens" for consensus.

The system's memories are not stored as in a computer but are produced by the whole. What is encoded in memory are the values of the connection weights. Disturbed by the right input, and given the connection weights, the net settles into a state that is the remembrance; that is, remembering is a process of network self-organizing, a settling into the recovered memory. This process of memory production also depends critically on self-tuning; the memory recovered depends on meaning, mood and motivation. Memories are not static entities that can be retrieved from storage bins but are fluid and influenced by a number of factors. This is why when we look back at our lives, the same event is remembered differently, depending on our current life situation. As we recontextualize events, memories of the past are actually formed anew. All the constraints enter in holistically in memory production.

Now our issue is this: Is it at least conceivable that a system built along these lines might be like Dasein? If this is not plausible, then at least for now, we may remain oblivious to the ontico-ontological Fact "no brain, no Da-Sein; no Da-Sein, no brain." My point is not to "prove" that a self-organizing system can do what Dasein does. I just want to try in the *Sprung* a little Round Dance (*Rundtanz*) between Heidegger's phenomenological ontology and connectionistic cognitive science and to be open to a harmonious *Spiegel-Spiele* (mirror-play) in mixing these discourses!

Does this hypothetical system, under tunable constraint that reflects affect/mood, drive and meaning, sound at all like Dasein? The system is spontaneous in operation and dynamical. It is unpredictable and free of rule following other than the tendency to settle toward states in which constraints are well satisfied. *Dasein is like this: a kind of free, spontaneous process that is most Dasein in "letting Being be."*

Of crucial importance, the system is situated in virtue of its self-tuning and resulting attunement. (I am using "attunement" in a wider sense than Heidegger, who thinks of it as a mood.) The tuning process by meaning, affect/mood and instinctual modules limits the possibilities. (This concept of tuning is functionally equivalent to what Heidegger thinks of as an ekstatic project.) Continually tuned for past, present and future, time is stretched as a constraint on the self-organizing process. That is, we are attuned for a past, a now and a future; this attunement changes from moment to moment. It is this continual stretching of time that Heidegger signifies by the expression "temporality temporalizing itself." Time is stretched by the dynamical movement of temporality; temporality tunes the nets. The nets thus tuned are "in" a world of meanings, ready to clear certain entities, situated.

In spontaneously moving toward constraint satisfaction, the nets problem-solve. This demonstrates a pragmatic know-how based in the whole,

not on serial rule-following. The probabilistic trait brings novelty by chance, but even more importantly, the law of the whole is sensitive to local influences. *Change something somewhere and everything changes because of the interconnectivity.* (This has become a familiar point through ecology: when the ecosystem is locally disrupted, as with destruction of the Amazonian rain forests, the whole of nature is affected.) A deeper novelty lies in such fluid changes of the whole. The process thus serves to settle into a pragmatic, knowledgeable and potentially creative solution for the multiple constraint satisfaction problem.

We can conceive, then, of a kind of system that is spontaneous rather than mechanically driven, self-organizing rather than other-organized, a system that is holistic and situated. It can find solutions to the multifaceted problems posed. This is a system rich enough in its functioning that Dasein might conceivably couple to something along these lines.

It was the Fact—"no brain, no Dasein; no Dasein, no brain"—that forced a break with the tradition and an openness to mirroring between Heidegger and cognitive science. What has been accomplished thus far is an exercise in looking. What has been achieved is a beginning sense that the holonomic system described, so fundamentally different from the computer that laboriously simulates it, may to some extent fit Dasein; however, the lack of fit is shown by the very strain of the effort to see the fit. This indefinite but suggestive outcome calls for more mirror-play. I break off the serial discussion here and pick up a new thread, "traversing" the domain of discourse (the discourse "space") just opened up along a new line.

3. Traverse along the line of presence

In the "traverse" we cover the same domain of discussion as above, but along a different line; or to shift from a skiing image to sailing, we set off on a different tack. The traverse is "upward" in that we bootstrap on the line already taken, for now when we consider Heidegger's philosophy, we can include cognitive science in our horizon. But this is not computational cognitive science whose technological exemplar is the digital computer. This is the connectionist cognitive science of self-organizing nets, whose properties are vastly different from the computer!

We begin the traverse along the line of Heidegger's focus on presence. (We might speak of Heidegger's focus on presence-to-consciousness, but "consciousness" introduces a dualism that Heidegger wants to avoid.) Prior to the *Kehre*—literally a "turn" in Heidegger's philosophy—presence depended on Dasein, whose Being is to be *Da*, "there," a "clearing" (*Lichtung*) where entities are brought to presence. Nothing can have presence without a Dasein for it to be present to. Heidegger (1962, p.37) states in *Being and Time* that "only as

long as *Dasein* is, is there (*gibt es*) Being." This opens Heidegger to the charge of subjectivity, for Being (presence) itself depends upon Dasein.

After the *Kehre*, there are two incompatible solutions that Heidegger offers to the problem of presence. (I make use of Olafson's treatise on Heidegger here.) In the first solution, entities already have presence without Dasein. Presence is a kind of "gift" that is available for Dasein to accept thankfully. But this presence is peculiar, Olafson says, in that "entities are indeed present, but presence as such is forgotten or hidden — that is, is not itself present."[5] A presence that is not present surely warrants our close scrutiny. Olafson further explicates Heidegger's position.

> Heidegger speaks of the "unthought unhiddenness of entities" as equivalent to "unthought being;" and this is further explicated as meaning that although "being itself is (*west*) as the unhiddenness in which entities are present, this unhiddenness itself remains hidden as what it is. (p.167)

This is terribly confusing, an unhiddenness that is hidden as to what it is. Of what does this unhiddenness consist then?

The only presence that Dasein understands (at least pre-ontologically) is presence that is thought. Any "unthought being/presence" is not party to our existence. The status of unthought presence is accordingly purely metaphysical. Pre-*Kehre*, as Olafson puts it, existence for Heidegger was the ground of presence (hence the charge of subjectivity). But after the *Kehre*, Olafson thinks, presence became the ground of existence. However this first post-*Kehre* solution founders in the Heideggerian fog of a presence that is not present.

The second post-*Kehre* solution—and finally our cognitive science ears can prick up—retains a role for Dasein. (As Olafson discusses, "Dasein" lives on in Heidegger's writings as "man," or "man as man." I use the term 'man' to be more faithful to the German.) Now man/Dasein contributes to a larger process, but no longer as a ground of presence. Instead something interactive is going on.

In the second solution to the problem of presence, presence arises in the *relatedness* of man and Being. Man is "the being who perceives Being by standing within true time." Man and Being need each other for presence to happen. "It is man," Heidegger says, who is "open toward Being, who alone lets Being arrive as presence" (Heidegger, 1969, p.32). In needing the openness of a clearing for the arrival of presence, Being remains "appropriated" to man. But at the same time, "A belonging to Being prevails within man, a belonging which listens to Being because it is appropriated to Being" (p.31). *Presence thus arises only in the mutual appropriation of Being and man.* "For it is man, open toward Being, who alone lets Being arrive as presence" (p.31). Again, "...for only with us can Being be present as Being, that is, become present"

(p.33). So it is clear that "Being" for the second solution requires a mutual appropriation with man.

In a closely related formulation, presence arises in the relatedness of time and Being, where time is an openness. "Time-space now is the name for the openness which opens up in the mutual self-extending of futural approach, past and present."[6] So presence may be said to arise *in the relatedness* of man/Dasein/time and Being.

Bootstrapping on the earlier discussion of self-organizing nets, we understand this relatedness as the relatedness of constraints due to different sources. That is, one constraint is due to the input from that which is other; this is the constraint from other beings. Different sets of constraints are due to learned connection weights and self-tuning. Since self-tuning has already been connected with time, we may say that this constraint arises within man as standing within the openness of time. In the cognitive science description, presence arises in the relatedness of self and other constraints on the self-organizing net.

Here man and Being are not grounds but are themselves grounded in the primary Event, *das Ereignis*. "It gives time; It gives Being."[7] The belonging to each other, the mutual appropriation of man and Being in the *Ereignis*, is not a static process, as it is presented in *Time and Being* or *Identity and Difference*, but is a holodynamic inter-play, a mirror-play, a coming-into-harmony of the whole. Man/Dasein/time and Being are given in the Event and their mutual appropriation has a process character of ringing mirror play, a *Spiegel-Spiele* in which the manifest world comes to presence out of the interplay of man and Being.

What may be especially difficult to imagine here is the "flowing" nature of the self-organizing process and its fit with the flow of Heidegger's mirror-play. I shall try to put it more concretely, freely mixing discourses. The Dasein provides a "place" for the lighting process in virtue of its self-organizing nets. The process of the nets is under constraints that change fluidly. One fluid constraint derives from the nets' surround, from other, from beings. Another fluid constraint, self-tuning, comes from within, from temporality. The constraints change flowingly and the net spontaneously moves towards maximizing harmony; the whole is a playful dance of mutual fitting. The lighting process is the flowing self-organizing process in which Being and man or Being and time are not polar opposites to be brought into relation through some dialectic but are always already assimilated to a whole.

The usual connotation of "mirror" can throw our listening off here. Being and man are not tweedle-dum tweedle-dee mirror-images. They are complements; they belong to each other and require each other for fulfillment. (Cf. how an imaginary number requires multiplication by its complex conjugate to become a real number.) The process of mirror-play is one of ringing, of matching, of finding the best fit between complements, the consensus that

achieves completion. Heidegger's Round Dance (*Rundtanz*) is a dance of the whole, the flowing self-organizing process in which the world comes to presence.

4. Traverse along the line of the to be

The preceding sections attempt to establish a discourse in which Heidegger and cognitive science can be discussed together. Opened by the fact that "no brain, no Dasein; no Dasein, no brain," my discussion tries to hear if Heidegger and cognitive science belong together. It is hoped that the possibility is at least worth considering. It must be admitted, however, that the putative "belonging together" can only be heard in selected instances. For example, in "Building Dwelling Thinking" and "The Thing" (Heidegger, 1971), the *Spiegel-Spiele* (mirror play) has a fundamentally different character from self-organizing nets. Given the multi-level richness of Heidegger's thought, and going against his intent, one must appropriate Heidegger by listening most attentively in selected places to make a cognitive science connection. With this admission of appropriation (which is, after all, but appropriating an appropriator), I shall again traverse the discourse space opened up, while bootstrapping on the preceding discussion, this time along the line of the "to be."

In early Heidegger it is clear that one of the senses of *Sein* is "to be." We *are* a certain being (entity). ("Viewed ontically, we are closest of all to the being that we ourselves are and that we call the Dasein; for we are this being itself."[8]) Since we are an entity, this question naturally arises: What is it *to be* this entity, the Dasein?

If the entity in question were a cabbage, we can properly say nothing about being a cabbage. After all, we are not cabbages, or candlesticks, or corsets, and so must remain silent regarding what it is to be such things. The one unique entity where we can properly speak up is provided by the Dasein. We even have a pre-ontological understanding of the whole thing, judging from our facile use of the word "is." We are directly acquainted with being (to be) the Dasein because that is our very existence. Put more perspicuously, we are directly acquainted with being the brain, embedded in the body, which is, in turn, embedded in a fluctuating energy sea. *To be this doubly-embedded brain system is to exist.* (Again, this is no reduction of existence to the brain posited by brain science but an equating of existence to *being* the brain that is posited by brain science.)

An ontological understanding of being the Dasein is provided by Heidegger's analytic of Dasein. The analytic of Dasein responds to the question of what it is to be the Dasein, which is first and foremost to be *Da* ("there"). The "to be" is taken over, however, by Da-Sein, in the linkage to the *Da*, and the "to be" the Dasein has been quite forgotten.

So Heidegger's analytic of Dasein is a hermeneutic of being (to be) the Dasein, a hermeneutic of *Existenz* (existence), whereas cognitive science in connectionist form is a hermeneutic of the brain *qua* abstract holonomic engine. The object of these discourses have a peculiar relationship: Cognitive science interprets a unique entity and the analytic of Dasein interprets what it is to *be* that unique entity. (We should not be surprised that the interpretations sound different; surely the hermeneutic of something ought to be different from the hermeneutic of being that something, just as the mere story of one's life is different from actually living it.)

The analytic of Dasein, then, describes what it is to be the very entity that cognitive science is concerned with in abstract machine terms. That such a close relationship has been mainly overlooked has something to do with the aforementioned conviction that ontology is the absolute ground of science, which forgets the uniqueness of that one science concerned with the Dasein's brain, and forgets the Fact that "no brain, no Da-Sein; no Da-Sein, no brain." But there are other factors worth noting that support concealment of the relationship between the analytic of Dasein and cognitive science.

After Heidegger's *Kehre*, the term "Dasein" and his *Existenz* fade away, replaced by locutions about "man." The *Da* doesn't get lost, however. Man remains an essential player in the lighting process. What drops out of view is *Sein*, so we easily forget that there is a *to be* involved in something like "man as man." The focus is instead overwhelmingly on the ground event that wondrously gives beings to be, the *Ereignis*. As Heidegger articulates the Event, the *to be man* slips out of unconcealment, and with it goes the link to cognitive science. In the context of the *Ereignis*, *Sein* is to be understood solely as presence. ("From the dawn of Western-European thinking until today, Being means the same as presencing."[9])

Cognitive science and the analytic of Dasein provide different hermeneutics (of something and being that something), yet they are connected in that *their articulations are coherent*. The *Spiegel-Spiele* between Heidegger and cognitive science may not be completely graceful, but there is a surprising mesh, an unexpected symmetry, especially considering how separate and irreconcilable the two are considered to be by advocates in both disciplines.

Whether or not the articulations are coherent is decided by the success of the *Spiegel-Spiele*. For example, the analytic of Dasein calls for a certain kind of brain system, and lo, the self-organizing system at least has something of the right stuff. So the call of the analytic of Dasein has been coherently answered to some extent. Cognitive science, in turn, calls for certain *existentalia*, i.e., characteristics of existence. For example, in the connectionist paradigm adopted here, which emphasizes tuning of the nets, Dasein ought to be attuned, which Dasein is, of course, in virtue of its situatedness. Here the analytic of Dasein coherently answers the call of the system.

Heidegger's analytic of Dasein and cognitive science are different, then, because an account of being (to be) something is different from an account of something, yet their articulations tend to be coherent when we put aside traditional beliefs and "listen" for the mirroring of one in the other, as I have illustrated above. Residual incoherence calls for more mirror play and is of heuristic value to both.

5. Comment

To recapitulate, in a playful *Sprung* we thought "Heidegger and cognitive science" and found support in the forgotten ontico-ontological fact "no brain, no Da-Sein; no Da-Sein, no brain." We saw that there are recently conceived systems that are Dasein-like in being situated and pragmatically knowing-how. Listening for coherence between Heidegger and cognitive science, we found coherence between the lighting process of the *Spiegel-Spiele* (mirror-play) and the self-organizing process of neural nets. We remembered the case of what it is to be the Dasein—what it is to be the doubly-embedded brain that cognitive science considers as abstract machine—and saw that it is *Existenz*. With these achievements, the *Sprung* grew serious.

Could it be that the seemingly vast gulf that separates postmodern continental philosophy from cognitive science—a gulf maintained with strong conviction from both sides—is but a custom founded on insufficiently examined traditions? Already in Anglo-American philosophy there are attempts to bridge the gulf, which Patricia Churchland (1986) bravely calls "neurophilosophy." I accordingly call for an openness to exploring the interface between facets of postmodern continental philosophy and facets of cognitive science, and I have attempted to warrant that call in the case of Heidegger and connectionist neural nets.[10*]

It should be noted that Heidegger's work is probably not the easiest place to launch such an attempt, however strategic this beginning. A more natural discussion might utilize the work of Jacques Derrida. Derrida has connected his focus on writing to early Freud in crucial ways, and via Freud's endeavor to think of the brain as a writing machine, there is a direct path to cognitive science. Bass has emphasized the importance of the machine and writing for Derrida and their unimportance for philosophy.

> Writing is always treated by philosophy as a *technique*, as part of the technology of communication, which always means the communication of truth and meaning. According to the traditional view, technology has no life of its own, and is to be kept below and apart from the living truth. Like writing. It is no accident, then, that the machine—the dead mechanism,

> which endlessly produces the same thing—should be as unthinkable for philosophy as writing (Bass, 1984, p.77).

Part II considers this "dead" mechanism and the writing of Derrida's key concept of *différance* in the light of connectionism.

II. Derrida and Connectionism: *Différance* in neural nets

The attempt to speak of continental philosophy and cognitive science in one breath is unconventional.[11*] On the side of continental philosophy (which I take to be the phenomenologic and existential *movement*, though that, of course, does not exhaust continental philosophy), conventional sentiment sees cognitive science in a certain historical role, as representative of the mainstream western *tradition*. Heidegger, arguably the most influential 20th century philosopher in this movement, traced the tradition to the Socratic philosophers. He held that the framework this tradition imposes—the *Gestell*—currently takes the form of technology (Heidegger, 1977). Heidegger strove to surpass the tradition or at least "leave [it] to itself."[12]

Heidegger's stance forces a certain attitude toward cognitive science. After all, cognitive science has sprung from information processing by machines, which since Heidegger's day have come to dominate technology. Thus cognitive science is thoroughly pervaded by the tradition. So when the conventional phenomenologic and existential movement looks at cognitive science, it sees the enemy. It has been left to Dreyfus[13] to engage that enemy, which he has done with great vigor.

On the side of cognitive science, there is an equally strong antipathy toward continental philosophy qua phenomenological and existential movement. The mutual antipathy here is not a dry intellectual thing, but is laden with strongly felt emotions that impede attempts at rapprochement. This antipathy can be easily heard in Churchland and Churchland's account of the artificial intelligence (AI) response to Dreyfus' claim that computers can't do what we Daseins can.

> Dreyfus's complaints were broadly perceived within the AI community, and within the discipline of philosophy as well, as shortsighted and unsympathetic, as harping on the inevitable implications of a research effort still in its youth...Time, it was felt, was on AI's side. Here again the impact on research was negligible. (Churchland and Churchland, 1990, p. 33)

Further, given the good working relationships with the Anglo-American philosophical tradition, mainstream cognitive science has been quite content to ignore continental philosophy.

Despite these general attitudes, which militate against any rapprochement between continental philosophy and cognitive science, I shall again try their borders in a particular region where I judge there to be some prospects for success. On the continental side, my attempt springs from the *oeuvre* (body of work) of the contemporary French philosopher, Jacques Derrida, whose "deconstructionism" is currently controversial in both philosophy and critical theory. I base the cognitive science side on recent connectionist models, rather than on the computational theory of mind, for, as will emerge from my discussion, there is a certain affinity between Derrida and connectionism, whereas Derrida and computationalism are inimical because of the latter's permeation by the *Gestell*, i.e., by the framework of the tradition.

1. Background

Since Derrida would, in principle, oppose any attempt to give his "essential" thought, I can only briefly indicate how I appropriate Derrida for present purposes.[14] After World War II, there was a crossing of French rationalism to Germany and German anti-rationalism to France.[15] Thus the spirit of Heidegger, in whom German anti-rationalism culminates, now surprisingly finds a home in France. Certainly Derrida[16] has been strongly influenced by Heidegger and frequently mentions him. (Hegel, Nietzsche and Husserl are also important influences.) But Derrida's focus is on expression through writing,[17] whereas Heidegger's focus was on Being. "Writing" is broadly construed by Derrida, including not only texts but speech, gestures, and, one might think by extension, the very story of one's life. His main concern is textuality, not presence.

Derrida's method of predilection is "deconstruction," which is an attempt to cope with the tradition that constrains our thought and insidiously invades the very language that we speak. Derrida and Heidegger typically refer to this longstanding western tradition as "metaphysics." Of course, those within the western tradition also repudiate "metaphysics," but they mean something else by the term, which means something else again in transpersonal psychology. I use the term "metaphysics" here to refer to that mainstream western dualistic tradition traceable to the Socratic philosophers, but I often speak simply of "the tradition."

The tradition, with its various dualities such as subject/object, sensible/intelligible and ground/derivative, is the unnoticed air in which our thought breathes. Forced to use terms imbued with metaphysics, Derrida does so only *sous rature*, under erasure, which is tantamount to Heidegger's literally drawing a cross over metaphysical terms like Being.) That is, since we have no

choice but to use a language imbued with metaphysical concepts, our only recourse in deconstructing the tradition is to erase the words, or cross them out, after we have used them. For example, Derrida is concerned with the "ground" of writing *sous rature*. The word "ground" usually implies the metaphysics of origin (*arche*) and serial, logical derivation (by *logos*) from the origin to an end point (*telos*), but Derrida's "ground" is without origin, and the process of change is without logic and unending. So "ground" with its accompanying metaphysical baggage is used and erased.

There is also a Freudian cast to deconstruction. Since metaphysics forbids certain paths of thought, Derrida scrutinizes texts that he is deconstructing with minute care, seeking out symptoms of metaphysical repression. Thus, he looks to the play of opposites, rhetorical flourishes, metaphors, polysemous words, and such marginalia (Derrida, 1982a) as format and footnotes to use as incision points for deconstruction. For example, in his playful and amusing, yet at the same time violent, polemic against John Searle, entitled *Limited Inc.* (Derrida, 1988), Derrida's deconstructive eye is caught by the first thing in a prepublication manuscript of Searle's: a copyright that Searle has placed on a manuscript that critiques Derrida. The ownership of the text preserved by the copyright is used as an incision point for a deconstruction of the metaphysical idea that texts have a stable authoritative meaning that can be passed on to readers. Derrida insists that nobody owns the expressions of discourse.

Much more might be said about deconstruction, but I shall close with a discussion by Derrida in an interview.

> To "deconstruct" philosophy...would be to think...the structured genealogy of philosophy's concepts, but at the same time to determine...what this history has been able to dissimulate or forbid, making itself into a history by means of this somewhere motivated repression. (Derrida, 1981, p. 6)

> All texts can consequently be read deconstructively as kinds of symptoms...of something that *could not be presented* in the history of philosophy, and which, moreover, is *nowhere present*, since all of this concerns putting into question the major determination of the meaning of Being as *presence*, the determination in which Heidegger recognized the destiny of philosophy. (Derrida, 1981, p. 6)

Of course, the self-conferred license to deconstruct by Derrideans is easily found irritating by those deconstructed and their proponents, which has given deconstructionism a bad name.

It must be admitted that the background given thus far, and indeed the bulk of Derrida's voluminous publications, are worlds apart from cognitive science. Derrida, however, has discussed Freud's (1966) early neural network theory, found in the post-humously published *Project for a scientific*

psychology of 1895, and has carefully followed Freud's machine conceptions to the paper "Notes on the mystic writing pad" some thirty years later (Freud, 1961). Derrida dismisses Freud's ideas about the brain as "neural fables," and, of course, the writing of the toy *Wunderblock* that caught Freud's attention is primitive and unbrainlike. Nevertheless, Derrida's discourse is in the vicinity of cognitive science through his discussion of Freud's brain model. It is this opening that I try to exploit here.

The opening between Derrida and cognitive science through Freud has another justification. Although Freud's psychoanalysis has not remained aloof from cognitive science, it has seemed necessary to jettison or palliate his "economic theory" regarding dynamic neural energies to bring Freud to the computer.[18] The economic principles of brain functioning, as thought through by Freud in his libido theory, were *thermodynamic*. (Freud was strongly influenced in this regard by Helmholtz and Fechner.) For example, there is a spontaneous tendency toward energy reduction in Freud's neural networks. Freud called this the "pleasure principle" and modeled it on the second law of thermodynamics. It takes energy to deflect this dynamic tendency, under the "reality principle." Computers, of course, are not ordinarily conceived of as thermodynamic engines but can simulate them.[19*] Connectionist neural nets are dynamical systems, that is, systems that change over time, to which thermodynamic equations can be applied. So there could well be a certain thermodynamic affinity between Freud and connectionist neural nets, and through Freud a path to Derrida; at least that is what I will explore here.

2. *Différance*

Any attempt to explain *différance*, a neologism that combines difference and deferral, quickly runs into principled resistance on the part of Derrida. *Différance* is neither a word nor a concept, nor does it have an essence. It is instead a "sheaf" which Derrida assembles in various ways.

> ...the word *sheaf* seems to mark more appropriately that the assemblage to be proposed [i.e. *différance*] has the complex structure of a weaving, an interlacing which permits the different threads and different lines of meaning—or of force—to go off again in different directions, just as it is always ready to tie itself up with others. (Derrida, 1982a, p. 3, bracket added)

Furthermore, *différance* is never present as such. "...it has neither existence nor essence. It derives from no category of being, whether present or absent."[20] There is not even a place to begin to trace the sheaf of *différance*. "For what is put into question is precisely the quest for a rightful beginning, an absolute

point of departure, a principal responsibility".[21] *Différance* is not even conserved over time, for it "lends itself to a certain number of nonsynonymous substitutions, according to the necessity of the context."[22] Indeed, *différance* itself drops out of Derrida's evolving texts.

So Derrida is not interested in *différance* as a definable concept. As he says in another context, "...the misfortune is to have a meaning, a single invincible meaning."[23] Any attempt at a systematic exposition of *différance* is thus encumbered and diffused at the very outset by Derrida's deconstructionism. He refuses to be pinned down in principle; semantic fluidity is his hallmark. "In the delineation of *différance* everything is strategic and adventurous."[24]

Derrida, however, does "attempt a simple and approximate semantic analysis [of *différance*] that will take us to within sight of what is at stake."[25] The French verb *differer* (Latin *differre*) has two distinct meanings: to defer and to differ. Derrida intends *différance* to refer to both meanings. "*Différance*...is immediately and irreducibly polysemic," that is, has multiple meanings.[26] Although difference/deferral by no means exhausts the reference of *différance*, I think that they are the most prominent strands of the sheaf and will at least "take us to within sight of what is at stake" in attributing *différance* to neural nets.[27*]

In what follows, *différance* should be understood as a dynamical "ground," a "basis" that is a movement, a flowing "foundation," with the words in quotes used *sous rature*. As a dynamical movement, force and energy concepts enter in, so *différance* has what Derrida calls an "economy." The dynamical play of *différance* is a condition for the possibility of difference and delay, where, as we shall shortly see, difference is understood through Saussure (1966) and delay through Freud (1966). Let's consider difference/deferral and listen for its operation in neural nets.

3. The difference of *Différance*

For Saussure (1966) signifiers and signified are united in the sign; signs are "two-sided." Signs participate in a system of differences, i.e. in a web of relationships of opposition, similarity, and substitutability. A particular word or concept is not meaningful in isolation but only within a complicated network of other words or concepts.

> Language is a system of interdependent terms in which the value of each term results solely from the simultaneous presence of the others...(Saussure, 1966, p. 114)

> ...concepts are surely differential and defined not by their positive content but negatively by their relations with the other terms of the system. (Saussure, 1966, p. 117)

We are used to thinking that words "have" their own meaning, so Saussure's claim that meaning is embedded in a system of relationships is disruptive. Saussurian difference is thus decidedly *holistic*. A sign is meaningful not in its own isolated plenitude but only in the whole in which it is embedded.

Saussurian difference is also very much to be found in Freud, Derrida points out.

> ...ideas, thoughts and psychical structures in general must never be regarded as localized in organic elements of the nervous system but rather, as one might say, *between* them, where resistance and facilitations provide the corresponding correlates. (Freud, 1953, p. 611)

For Freud, too, it is the relationships (as determined by resistances and facilitations) that determine meaning.

In the movement of *différance*, then, the "ground" becomes "differentiated," each difference distinguished in relation to the whole. So *différance* as a dynamical event differentiates a whole network of relationships.

Let's listen for the difference of *différance* in neural nets in the now quite familiar connectionist story. Neural nets are composed of nodes that are richly interconnected. Connections between nodes carry influence that may be excitatory or inhibitory. An activation function at the node determines the nodal output given the input influences. The value of an adjustable weight on each connection controls the amount of input influence that passes through the connection. These weights are adjusted in learning.

The pattern of connections is the fixed wiring diagram of the net. The adjustable weights constrain the network operation and carry the net's "knowledge." Because of the rich interconnectivity, the net always operates as a whole. The nodes that comprise the net are thus distinguished by virtue of their functional interrelationships. What distinguishes a node is its pattern of weighted primary connections that secondarily open to the whole.

The sign qua signifier/signified is also a node in this sense of having a pattern of complex relationships to other signifiers/signifieds and through them to the whole. So language as a system of interdependent signs can be thought of as a neural net, with each sign assigned a node. Saussure gives the instructive example of the French sign *mouton* which compared to the English sign *sheep* has a different "value"

> because in speaking of a piece of meat ready to be served on the table, English uses *mutton* and not *sheep*. The difference in value between *sheep* and *mutton* is due to the fact that *sheep*

> has beside it a second term while the French word does not. (Saussure, 1966, p. 116)

In network terms, English has distinct, mutually facilitating nodes that represent, i.e., can be semantically interpreted as, *mutton* and *sheep*, whereas in the network for French there is only one node that represents *mouton*. Thus the connectivity of *mouton* and *sheep* differs. Saussurian "value" lies in the connectivity.

So the difference of *différance* is like the difference in neural nets: in both there are nodes which are foci of relatedness embedded in a complex network of relationships. These nodes open two ways to the whole: the whole fans in on the node and the node fans out to the whole. In the linguistic case, the node is a linguistic sign (signifier/signified), and in the network case, a neuron, but abstractly considered they are equivalent. The difference of *différance* thus makes good sense in connectionist terms.

It is important to appreciate here that *différance*, as a movement, produces difference and thus produces meaning. It is *différance* that is "original" (*sous rature*), not present meanings. *Différance* is the condition for the possibility of meaning, present or absent. Connection weights are the condition for the possibility of meaning in neural nets. The unweighted wiring diagram is semantically uninterpretable. The network representation of meaning depends on connection weights. So the difference of *différance* can be found in neural nets, as a function of the connection weights. With this result, the traditional problems of artificial intelligence begin to open, at least in principle, to the textuality and discourse that have been Derrida's main concerns.

4. The deferral of *différance*

To get a quick metaphoric take on "deferral," we can imagine taking a trip from Los Angeles to San Francisco qua pleasure object. The easiest and fastest route is by the freeway system that passes through the central valley. But for one reason or another—the heat or the boredom—we may take the more difficult and slower Pacific Coast Highway, which *defers* our arrival in San Francisco. As we approach San Francisco, we might be forced into a series of detours that continually route us around San Francisco and, in Kafkaesque fashion, never arrive at our destination, which is always *deferred*. Here we are ever on the way (like don Genaro's "journey to Ixtlan[28]).

To understand the deferral of *différance* more deeply, we must recall Freud's metapsychology, which was conceived under the influence of 19th century thermodynamics. Freud's version of neural networks supports chains of memory traces. The network economy is governed at the most basic level by the pleasure principle, as we have seen. The spontaneous movement of Freud's

net is for neural excitation to flow by the most direct path available to the memory trace of the instinctual object whose presence has brought gratification and drive reduction. (According to the pleasure principle, we take the central valley freeway to attain the instinctual object, San Francisco.) Thus under the pleasure principle the net spontaneously moves toward the memory of the instinctual object as directly as possible. But there is a second principle superimposed, the reality principle, in which "facilitations" are employed so that, in the interests of adaptation, a detour is taken from the direct path to the memory of the object. The detour may be permanent—there is a "defense"—and the memory is never reached. (Given the defense, we are ever on the way to the instinctual object.)

Just so for *différance*, Derrida says. There are delays, postponements, deferrals, *temporizing* in the play of *différance* so that an inscription is put off. According to Derrida (1974), writing itself has been historically deferred, at least since the time of Plato, in favor of speech. (Derrida calls this "phonocentrism.") The very history of metaphysics is a

> system of logocentric repression which was organized in order to exclude or to lower (to put outside or below), the body of the written trace as a didactic and technical metaphor, as servile matter or excrement. (Derrida, 1978, p. 197)

So something is not written, or not said, or doesn't come to mind, or is not lived out, through the deferral of *différance*. It is not that an already constituted presence is deferred; all presence is engendered through *différance*. In deferral, alternative paths of writing are opened up; the direct path is "broken, cracked, *fracta*, breached"[29] in the tracing of new paths. In the sheaf of the movement of *différance*, difference constitutes meaning, and deferral determines which meanings are absent and which alternative meanings are present.

The deferral of *différance* is where dynamical economic notions enter, so we must now consider the well known economy of neural nets and listen for deferral. These nets are explicitly considered to be dynamical systems to which thermodynamic equations apply. The dynamic is the spontaneous tendency of the self-organizing net to optimize multiple constraint satisfaction (enhance "self-consistency"). The economy tends toward consensus of the whole. It is the connection weights that constrain network self-organizing. Multiple incompatible constraints can be encoded in the connection weights. Input to the net poses a problem under these conflicting constraints. The network economy finds a good enough solution to the multiple constraint satisfaction problem thus posed, settling into a good enough consensus across constraints.

This economy is quantitative in that the energy of any network state can be calculated.[30] When the resting net is disturbed by input, the energy of the resulting state is raised. The net then spontaneously reorganizes under the

constraints to a state of low energy. (The "energy" reduction here should not be confused with increased entropy; Hopfield and Tank call it the "computational energy.") With self-inconsistency this energy is high, and decreases as the net spontaneously self-organizes toward self-consistency.

There are a number of low energy states that the disturbed net might "relax" or "settle" into, each associated with a probability. The spontaneous settling of disturbed neural nets into low energy states is a stochastic, i.e., probabilistic, process, so that the net "playfully" moves toward *self-consistency*. Thus the state the net relaxes into achieves a good enough harmony. So the economy of the net is to move probabilistically toward ordered, self-consistent, low energy states.

Now, it may not be easy to imagine deferral in neural nets, because of the problem domains of typical concern to artificial intelligence and because of current implementation limitations, but it is not difficult to conceive of deferral. Conventionally, the weights are adjustable, changing relatively slowly during learning, and remain relatively fixed. Now we imagine that these adjustable weights are continually modulated; there is a fluid "tuning" of the constraints on the nets provided by the connection weights. Let's see how this works out in the memory domain.

A memory is a network state with low energy. More carefully put, *the remembrance is a network state with low energy*. Memory as "remembered" should be distinguished from the "memory trace," which we also confusingly call the memory. (Freud, for example, equates activating the memory trace with having the memory.) The memory trace is a constraint encoded in the connection weights, whereas the remembrance is a settlement under that constraint.

Remembrance is achieved, then, by the net settling into a certain low energy state. It is as if the net is "attracted" to the memory whenever its state is in the vicinity. The memory (remembrance) of the instinctually satisfying object is a very powerful attractor, so the network moves toward it from a variety of starting points; it has a wide "basin of attraction." Under basic conditions (i.e., Freud's "primary process"), the spontaneous tendency of the net is to settle into the dominant attractor as quickly and directly as possible. The net thereby spontaneously reduces its energy just as Freud's mental apparatus, when charged with instinctual energy, spontaneously discharges its energy under the pleasure principle (Freud, 1953).

It is helpful to "picture" the process just described in terms of a "state space." Because this "space" has more than three dimensions, it cannot be visualized; it is a "hyperspace" of N dimensions. (Although hyperspace is not imaginable, a two-dimensional Poincaré section through the hyperspace can be taken, as in Figure 3.1.) Each dimension of the hyperspace represents the values of a particular variable. A system characterized by N variables can accordingly

be represented by a point in an N dimensional hyperspace. (In Figure 3.1, where only 2 variables are considered, the system is represented by a point in a plane.)

Now the *state* at time t of a net with N nodes is defined as *the values of the N outputs of those nodes* at time t. Thus the state is characterized by N variables, each of which is represented by a dimension in an N-dimensional space. The state of the net at t can accordingly be represented as a point in an N-dimensional state hyperspace. Every possible network state lies somewhere in this state space which is an abstract "plenum" of possible states. A sequence of states over time follows a path (a trajectory, a flow) though the N-dimensional space. We can picture, then, the network changes as a path in a hyperspace.

Each point of this hyperspace has a certain number associated with it, which represents the energy of the state represented at the point. (This energy is represented on the third dimension in Figure 3.1, providing an "energy landscape.") Since low energy means high probability, each point of state space has an associated probability. The network economy is such that the paths in state space spontaneously tend toward high probability "attractors" and tend away from low probability "repellors," that is, the paths tend downhill on the hyperspace energy landscape. Memories of instinctual satisfaction are powerful attractors. Paths, too, are associated with probabilities.

In tuning, connection weights are modified so that what had been the most probable paths through state space to the attractor are breached and alternative paths opened up. Because of tuning, the net may never again settle into that attractor which is the remembered instinctual object, i.e., that attractor

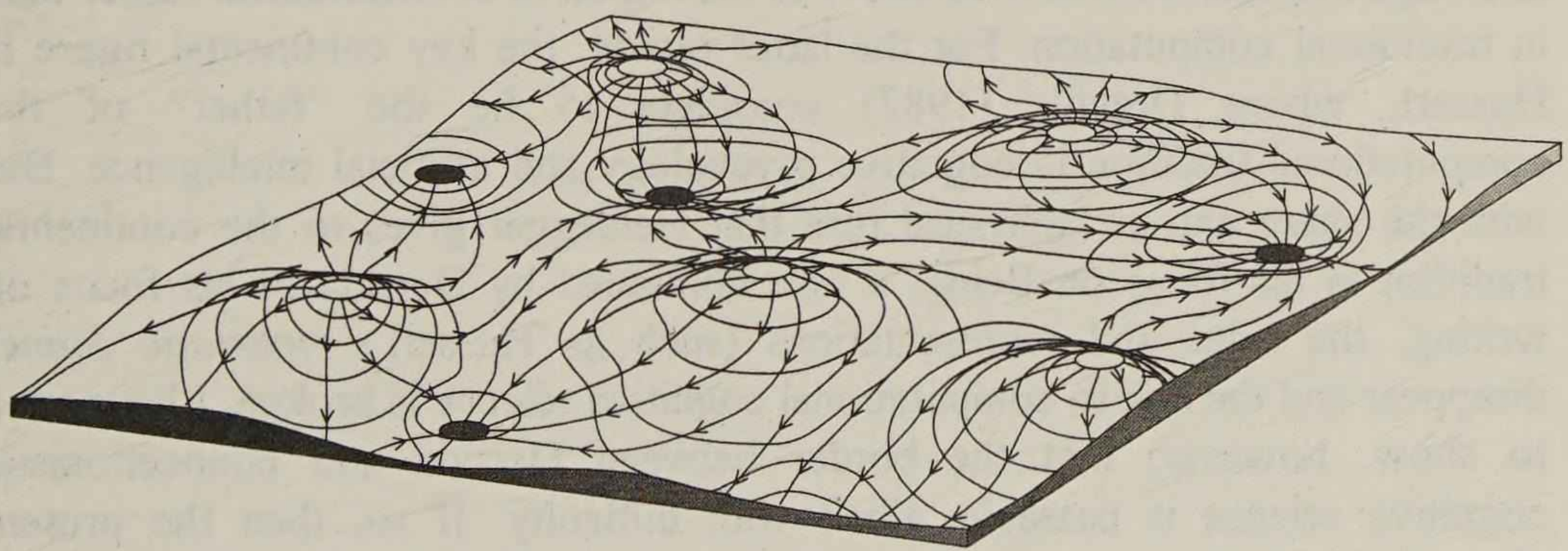

Figure 3.1: Poincaré section of state hyperspace with an energy landscape. Filled circles represent attractors and unfilled circles represent repellors. Arrows show possible downhilll trajectories of the system.

is permanently avoided, resulting in a permanent defense. (Imagine an attractor in Figure 3.1 completely completely surrounded by a high mountain chain. Since the trajectory heads downhill, a detour will be made as that attractor is approached.) Tuning thus forces a detour from what was the highly probable "primary process" path through the network state space, that is, a detour from the primary process path that ends in the attractor state which is the memory of instinctual gratification. The detour is accomplished by shifting the tuning so that there is a breaking into new "secondary process" paths that remember surrogate objects (e.g., a teacher rather than mother or father).

An attractor might be some other mental content than a memory: it might be writing, saying, or a behavioral act. Tuning of the connection weights can defer these too. So tuned neural nets can also show the deferral of *différance*. Tuning alters the probabilities and thus deflects the flow from the high probability path, as in Freud's secondary process. The delay due to tuning brings flexibility to network functioning so that realistic adaptation can take place.

To summarize, the difference of *différance* depends on the weighted connectivity of neural nets (i.e., the memory trace) and the deferral of *différance* depends on tuning the weights, which alters the probabilities of paths in the network state space so that the most direct path to the attractor is breached and alternative paths opened. *Neural nets realize difference/deferral: The operation of différance is characteristic of neural nets.*

5. Comment

It is noteworthy that the border between postmodern continental philosophy and cognitive science was tried above in the region of connectionism rather than in traditional computation. For the latter region, the key continental figure is Husserl, whom Dreyfus (1982) considers to be the "father" of the computational tradition in cognitive psychology and artificial intelligence. But with the sharp anti-metaphysical turn that Heidegger gives to the continental tradition in his focus on Being, a turn continued by Derrida in his focus on writing, the rules and representations (such as Husserl's *noematic Sinne*) disappear and the link to computational cognitive science is broken. I have tried to show, however, that the border between Derrida and connectionistic cognitive science is passable, albeit with difficulty. If so, then the present discussion aids in opening a discussion too long deferred in the *différance* of contemporary discourse.

From the Derridean standpoint, dialogue with brain science cannot even begin *until the concept of brain has been deconstructed*, for the concept of brain, like all concepts, is caught up in the *Gestell*, i.e., snared in the traditional

metaphysical framework within which the west has operated since the time of Socrates. Thus what is required is both brain deconstruction and construction of postmodern brain theories. The "metaphysical brain" of the *Gestell* to be deconstructed is none other than the brain computer and the associated computational theory of mind (e.g. Fodor and Pylyshyn, 1988). I have showed constructively that *the "postmodern brain" which meshes with Derrida's sheaf of différance is a connectionist system whose processes are spontaneous, unpredictable, non-logical, self-organizing, self-tuning and holonomic.*

CHAPTER FOUR

TOWARD A NONCOMPUTATIONAL COGNITIVE SCIENCE: THE SELF-TUNING BRAIN

The theory that the brain performs computations is so widespread in cognitive neuroscience, and so strongly held, that its status is "paradigmatic" in Kuhn's strong sense. It is difficult to even think of brain computation as a "theory" until alternatives are seen, so deeply rooted is the information processing idea in current thought. The stated purpose of *The Journal of Cognitive Neuroscience*, for example, is to publish papers that "bridge the gap between descriptions of information processing and specifications of brain activity." Indeed the "ultimate aim" of "computational neuroscience" is to "explain how electrical and chemical signals are used in the brain to represent and process information" (Sejnowski, Koch and Churchland, 1988, p. 1299). There is no more tightly held belief in the disciplines that comprise cognitive science than the idea that the brain processes information. This belief in information processing is quite transparent for contemporary cognitive science.

Daugman reminds us, however, that computation is a *metaphor* of brain function.

> Surprisingly, given the pervasive popularity of this metaphor, there remains today no well-established evidence of symbolic manipulation or formal logical rules at the neurobiological level in animal physiology. · ...while the computational metaphor often seems to have the status of an established fact, it should be regarded as an hypothetical, and historical, conjecture about the brain...Today's embrace of the computational metaphor in the cognitive and neural sciences is so widespread and automatic that it begins to appear less like an innovative leap than like a bandwagon phenomenon, of the sort often observed in the sociology and history of science. (Daugman, 1990, p. 15)

Emcouraged by Daugman's caveat, I propose an alternative theory that brain functioning is *not* computational. This alternative theory is a "radical" form of connectionism (neural net theory).

The alternative is labeled "radical" because current connectionism fully accepts the computational view. The neural nets of the brain are performing

computations, it is thought, though not as desktop computers do. There is no programmed, logical processing of information in real neural nets; the processing is differently performed. Nonetheless, there is a computation going on, a "subsymbolic" computation, as Smolensky (1988) argues, not the conventional symbolic one, as Fodor and Pylyshn think. This computation is naturally expressed by the mathematics of linear algebra (Jordan, 1986), in which the computation is thought of as the mapping of an input vector to an output vector.

The meaning of "computation" requires some comment, since it is so central to what follows. Churchland, Koch and Sejnowski (1990) attempt to define computation in their discussion, "What is computational neuroscience?" They consider a physical system "in a most general sense" to compute a function f(x) when there is

> (1) a mapping between the system's physical inputs and x, (2) a mapping between the system's physical outputs and y, such that (3) f(x) = y. (p. 48)

This input-to-output mapping gives a "weak" sense of computation, since *how* the mapping is accomplished is left unspecified. But they also give "a suitably broad notion of computation" that is "strong," filling in how the mapping is actually done.

> It is useful...to class certain functions in the brain as computational because nervous systems represent and they respond on the basis of the representations. Nervous systems represent the external world, the body they inhabit, and, in some instances, parts of the nervous system itself. (p.48)

Thus the performance of the computation is accomplished through the use of representations. Furthermore, the explanation of state transitions in the performance of the computation "describes the states in terms of the information transformed, represented and stored" (p. 48). So "computation" in the strong sense is tantamount to information processing. In the weak sense, the term vacuously skirts the issue of how the computation is actually done and thus is divorced from neuroscience. The term "computation" accordingly will be used in the strong sense in what follows.

The radical connectionism presented here holds that the brain does not actually perform computations—even though its competence might be computationally described, or Smolensky (1988) suggests, approximated by computation. My discussion begins with a critique of simplified neural nets modeled on the computer. Such simplified silicon nets can be thought of as computing, but biologically realistic nets are noncomputational. Rather than structure-sensitive, rule-governed operations on symbolic representations, there

is an evolution of self-organizing nonlinear dynamical systems in a process of "differing and deferring." (For a discussion of this process see Chapter Three, Part II.) This process is a neurochemical tuning of constraints on the evolution of the dynamical system. The brain can be described accordingly as "self-tuning" as it intersects input from its surround. (It should not be thought that there is a "self" within the brain that tunes; "self" refers here to the brain taken as a whole.) Then I compare a biologically realistic, molecular information processing model (Black, 1991) and the noncomputational model. Finally, I consider studies of hypothesized fractal properties of the brain, which provide some preliminary empirical support for the noncomputational model.

1. Simplified neural nets

Conventional cognitive science thinks that simplification of neural net models is unproblematic and consistent with strategies successfully applied elsewhere in science. Simplifying models "abstract from the complexity of individual neurons and the patterns of connectivity in exchange for analytic tractability" (Sejnowski, Koch and Churchland, 1988, p. 1301). Crick, in contrast, is dubious about the simplifying approach: "Most of these neural 'models' are not...really models at all, because they do not correspond sufficiently closely to the real thing" (1989, p. 131). Getting, similarly, talks of "crude network models" that are "still barren in comparison with biological systems" (1989, p.200), and Black speaks of "a virtual cell biological vacuum" and computational models that are "particularly impoverished compared to biologically based brain function." (1991, p.xii) Shepherd observes,

> One must conclude that there is at present a considerable mismatch between [artificial] neural networks and the real nervous system. A case could very well be made that the networks could hardly be less neural; that most of the properties believed to be neural are in fact not so or are only remotely so, and that many properties are introduced that are explicitly not neural (1990, p. 92).

Despite these strong doubts on the neurobiological side, neural net modelers remain confident that

> ...if the computational model is firmly based on the available experimental data, it can evolve along with the experimental program and help to guide future research directions. (Sejnowski, Koch and Churchland, 1988, p. 1305)

We shall see below that simplifying models serve to sustain the theory that the brain computes, whereas biologically realistic models open toward the possibility of a noncomputational neuroscience.

Simplified nets consist of formal neurons, i.e., richly interconnected "nodes." Signals fan in on the nodes and signals fan out from the nodes; the nodes open both ways to the whole network. There are input/output transfer functions at the nodes that determine output for given input. Connections between nodes ("connectivity") are excitatory or inhibitory, and there are adjustable weights on the connections. There are also network parameters such as signal/noise ratio, excitation/inhibition ratio and decay time that affect signal processing. The net is typically layered into three tiers: (1) an input layer on which an activation pattern is impressed from the outside, (2) a hidden layer where distributed processing occurs, and (3) an output layer that transduces signals to the outside.

During the operation of simplified nets, the connectivity, the connection weights, transfer functions at the nodes, parameters and input are kept constant. The net evolves as a dynamical system and settles into a state that optimizes satisfaction of the various constraints; a kind of compromise or consensus is reached across constraints. This process is not programmed but is self-organizing. The time it takes for the system to settle into an optimal state demarcates an event or "interval."

When nets learn, the connection weights, which control the amount of influence passing through the connections, are changed before the next trial; the weight changes constitute a memory trace. Connectivity, transfer functions, and network parameters are typically held constant from trial to trial; their settings can be thought of as static traces. Connection weights modified by learning provide dynamic traces in the simplified model.

The operation of simplified, artificial nets is typically described as computational.

> In a typical connectionist model, input to the system is provided by imposing activation values on the input units of the network; these numerical values represent some encoding, or representation, of the input. The activation on the input units propagates along the connections until some set of activation values emerges on the output units; these activation values encode the output the system has computed from the input. (Smolensky, 1988, p. 1)

Churchland and Sejnowski propose that information is processed by the computation in that "information provided as an input vector flows through the network, one layer at a time, to produce an output vector" (1989, p.28).

Even in the case of simplified nets simulated in silicon, however, the understanding of what counts as computation is severely stretched. For the

computational theory of mind, representations and combinatorial rules for transforming them provide a complete account of syntax.[1] All syntactical operations are on *local* tokens (symbols). In simplified nets, however, the *whole* must be taken into account in explaining the transformation of input to output. The representation is processed in distributed form. Since the explanation of change in representations must detour through the self-organizing whole, "global evolution" seems a more appropriate description than "local transformation," and threatens to deform the nature of computation as the tradition conceives of it.[2] The issue becomes irrelevant, however, when we consider living nets, which are essentially noncomputational; that is, they do not rely on rules and representations.

2. Biologically realistic nets

Although silicon simulations of complex biologically realistic nets are just beginning to be developed,[3] we know enough of the relevant properties of living nets to consider the possibility that something other than computation is going on. In living nets, everything is continually fluctuating: connection weights, transfer functions, parameters, input, and even the very connectivity, without leaving any traces of the fluctuation. As Getting states, "...the functional organization of many neural networks appears to be under dynamic control, changing in accordance with the conditions at the moment" (1989, p. 184). Black emphasizes that both the structure (hardware) and the functional organization fluctuate. "Extensive evidence indicates that the brain is not an immutable series of circuits of invariant elements; rather it is in constant structural and functional flux." (1991, p.3) Thus biological nets are chemically *tuned* moment to moment in many respects, some details of which will now be discussed.

The input-output transfer function at the node depends on ion channels that are exquisitely controlled by chemicals (neurotransmitters, neuromodulators, second messengers). For example, the chemically modulated bag cell neurons of *Aplysia* show a profound transformation of electrical properties during which the cells fire repetitively and their action potentials undergo significant increases in height and width.[4] Thus, there is chemical modulation of the input-output function. There are at least four distinct ionic conductances modulated for amplitude and kinetics by two different second messenger-protein kinase systems,[5] and all this affects the transfer function.

> Since repetitive firing properties reflect the expression of the underlying ionic conductances, modulation of the ionic conductances will alter the input/output relationship of a cell...The effects of modulators covers the range of intrinsic

> properties, including increased or decreased excitability, the modulation of spike frequency adaptation, the enhancement of post-inhibition rebound, the induction of plateau potentials, and the expression of intrinsic bursting. (Getting, 1989, p. 198)

In simplified nets, the input-output transfer function at the nodes is held constant; however, in biologically realistic nets, the transfer function is chemically modulated in exquisite fashion moment to moment without leaving a trace.

The connection weights of simplified nets are equivalent to the "synaptic efficacy" between living neurons. In learning, there are structural changes so that synaptic efficacy improves. (Increase in the value of the weight corresponds to increased synaptic efficacy.) For example, Lynch proposes that postsynaptic receptors buried in the cell membrane are excavated in learning and thus become available. The increase in available receptors to which neurochemicals ("ligand") in the synaptic space bind effectively improves synaptic efficacy. This structural change, *which results in a memory trace*, is modeled by changing the connection weights in simplified nets.

In real nets, however, synaptic efficacy also depends on moment-to-moment chemical modulation of transmitter synthesis, transport, release and reuptake;[6] this modulation controls the amount of ligand available. There is no memory trace here. Accordingly, *the connection weights, which simulate the synaptic efficacy of biologically realistic nets, ought to change fluidly, unlike the case of simplified nets.* For example, many central excitatory synapses have both NMDA and non-NMDA receptors (Bekkers and Stevens, 1989). The non-NMDA receptors are classical but the NMDA receptors depend on both ligand (glutamate) and on the neuron's transmembrane potential (Nowak et al, 1984). Since the membrane potential depends on the activity of other inputs, the activity of NMDA receptors is dynamically modulated by other active inputs.

Network parameters are also modulated moment to moment by chemical means. For example, noradrenalin is thought to improve signal/noise ratio,[7] and certain amino acids, such as GABA, controls excitation/inhibition ratio.[8] *So important network parameters, too, fluctuate in realistic nets, which changes their functioning.* Of course, input also is in continual flux in the ordinary unsimplified ecological case.

The very connectivity of realistic nets varies fluidly in several senses. Whether or not an action potential spike initiated at the axon hillock propagates past a branch point on the richly arborized axonic tree depends in part on its shape—broader action potentials are more likely to propagate past branch points—and the shape of the action potential is neuromodulated.[9] Neurochemically modulated frequency also affects propagation past branch points.[10]

A sharp distinction accordingly must be maintained between effective functional connectivity, where the spike reaches the pre-synaptic axonal terminals, and anatomical connectivity, since there is only a certain *probability* of transmitter release at each anatomical synapse.

> ...only a proportion (perhaps a few tenths) of the synapses in an active input array will release transmitter for a given presynaptic input. This suggests that, during natural behavior, a neuron is likely subject to activity in a relatively small proportion of the synapses on it at any given time... (Shepherd, 1986, p. 95)

Thus *functionally effective connectivity in the brain fluctuates under chemical control* rather than remaining constant, as happens in simplified, artificial nets.

There is still another sense in which the connectivity varies. Multiple transmitters are co-localized in neurons, and many of them are independently expressed, regulated, and used as a function of the environment. The result—a variable and differential expression of the genes that encode transmitter molecules—"leads to continuous change in the transmitters synthesized by any single neuron" (Black, 1991, p.7). As the relative proportions of co-localized neurotransmitters varies, the connectivity varies.

> Within a single (neuroanatomical) pathway, chemical circuits form, dissolve, and reform, in response to environmental cues. Changing chemical pathways are thereby impressed on a substrate of relative gross anatomic stability. (Black, 1991, p. xiii)

Thus, *both the functional connectivity and the chemical pathways fluctuate in biologically realistic nets.*

To **summarize**, in biologically realistic nets the connectivity, connection weights, nodal transfer functions, network parameters and neurochemical expression can change fluidly under chemical control: *the nets are chemically tunable* moment to moment, leaving no trace, only a fluctuating attunement. The brain system is *self-tuning* as it meets its surround.

3. Noncomputation in biologically realistic nets

In simplified nets, as discussed above, the outside is re-presented inside, and the distributed representation is processed. It is the processing of representations that qualifies simplified nets as computational. In realistic nets, however, it is the self-organizing *process* as such that changes as a function of chemical modulation.

Furthermore, it no longer makes sense even to talk of "re-presentations." The input flux (both from the environment and from endosomatic instinctual and emotional sources) provides a shifting constraint on the self-organizing process, together with other flowing constraints due to chemical modulation of connectivity, connection weights, transfer functions, parameters and neurotransmitter expression. *The outside is not re-presented inside but* ***participates*** *on the inside as but one constraint on a self-organizing process.* In effect, the other tunes the brain via input. Thus there is an interaction between input as other-tuning and self-tuning, out of which a constraint-satisfying settlement appears. (This is a connectionist version of Neisser's dictum: Perception is where cognition and reality meet [1976, p.9]. In the present connectionist terms, *cognition tunes* and its "meeting" with reality results in a "settlement.") Once the theory of information processing is let go of, then an interaction between participatory self and other, as constraints on a nonlinear, dynamical, self-organizing process, can be thematized.

The brain permits participation. Neural nets are a place where the outside and the inside meet and participate in a whole, a place where cognition, memory and reality join. The outside's influence appears in two forms: activation patterns on an input layer and memory traces carried by the connection weights in the hidden layers. The inside's influence is in two forms: recurrent input that loops back after downstream processing (Churchland, 1989; Edelman, 1989) and self-tuning. Out of that intersection of "self" and "other," the dynamical whole evolves in its spontaneous, unexpectedly bifurcating manner. So the brain does not compute; it permits and supports "participation" by self and other in the evolving whole.

4. State space formulation

The difference between computation in simplified nets and noncomputation in realistic nets can be presented in terms of "state space." (A two-dimensional state space is represented in Figure 4.1.) The state of the net is given by the activation value for each of its N nodes. The network state, then, is represented by a point in an N-dimensional space ("hyperspace") whose N dimensions represent the activation values of the N nodes. State change over time is represented by a trajectory (path) in state space. Hyperspace additionally has a topography (portrayed as the third dimension in Figure 4.1). States that well-satisfy the constraints lie in basins, whereas states that poorly satisfy the constraints lie on peaks. Peaks are "repellers" and basins are "attractors." The spontaneous tendency of the net is to move "downhill," i.e., toward attractors, optimizing constraint satisfaction.

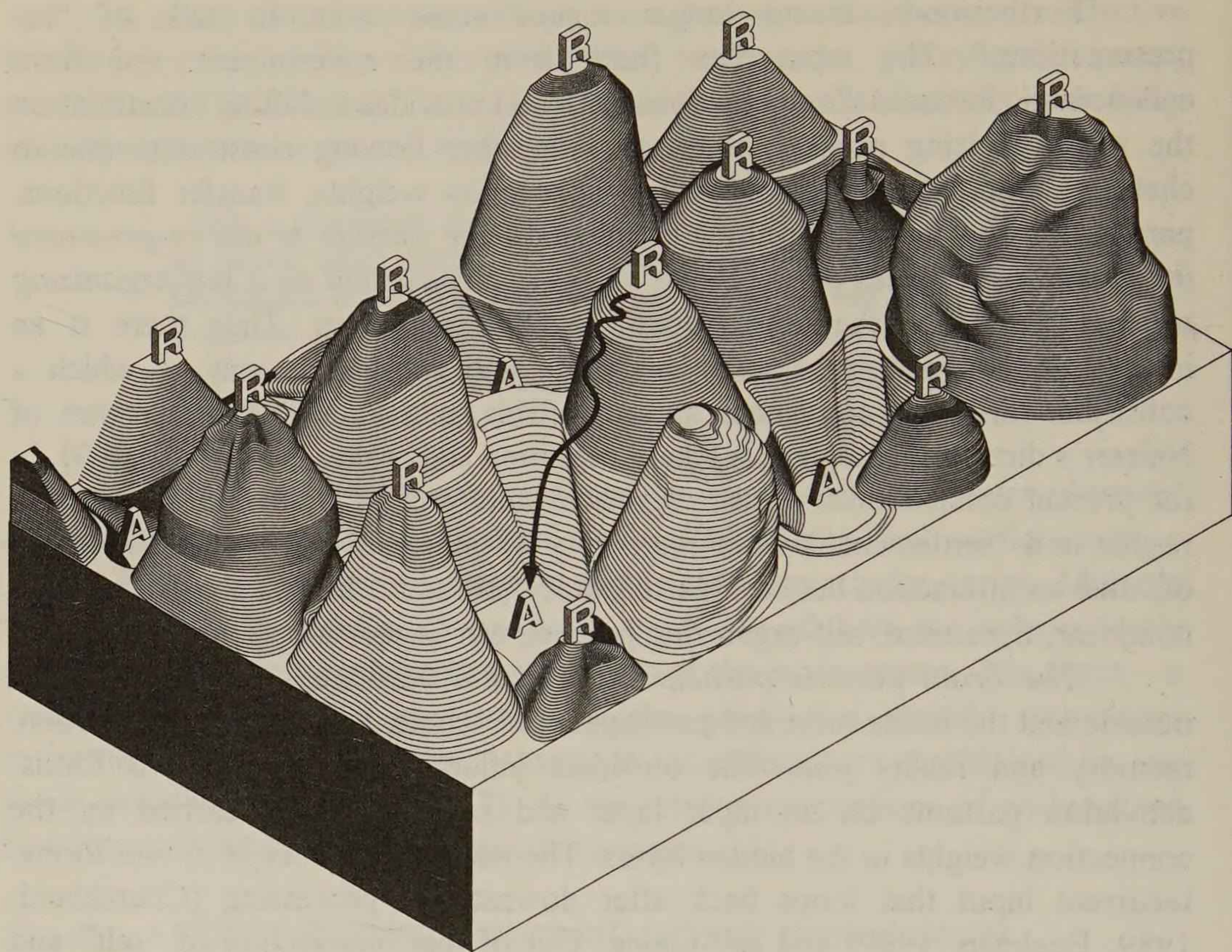

Figure 4.1: Topological surface in the state space of the dynamical system. The figure illustrates a two-dimensional plane section of an N-dimensional manifold or hyperspace. The third dimension reflects constraints on the evolution of the system states. The trajectory (arrow) moves away from repellors and toward attractors (from Rs towards As), that is, "downhill," as the system spontaneously self-organizes.

Symbolic computation is not usually thought of in state space terms, but there is no impediment to doing so. At every stage of the computation, the N digital components of the computer are in a particular state (on or off), and during the serial computation a trajectory is traced in the computer's state space. Given the input to the computer and a program, the resulting trajectory is fixed. This gives state space a peculiar two-level topography in the case of computation: the entire trajectory lies in the bottom of a deep canyon with vertical sides, and all other points of the state space lie on the mesa. There is no "downhill," hence no spontaneity; in the case of symbolic computation, the trajectory has the probability 1.0.

In the case of subsymbolic silicon computation, given the input and the constraints, the resulting trajectory is not fixed but has a fixed probability. The topography here is "normal" in that there are variegated peaks and basins; depending on which region of state space the input shifts the net to, the net settles into one or another basin. The trajectory here is spontaneously followed. So in symbolic computation the result is fixed, given the input and the program, whereas in subsymbolic silicon computation, the theoretical probability of the result is fixed, given the input and the constraints. Program and constraints correspond in terms of exerting control, but the former's control is absolute whereas the latter's control is probabilistic.

In the case of living nets where there is continual tuning going on, not even theoretical probabilities are fixed; they change moment to moment, which gives an *autodynamic* property to network functioning. The topography is decidedly abnormal: it continually fluctuates. The network's task is reverse Sisyphean: no sooner does the net settle into a state then the topography changes because of tuning, so that very state may now lie on a peak and it is downhill all over again. Horn and Usher have modeled nets with dynamical thresholds that are autodynamical even in the absence of any external stimulus.

> The network starts its dynamical flow from some initial condition and when properly tuned, goes on forever wandering around in pattern space [state space]. (Horn and Usher, 1990, p.256, bracket added)

Results, then, are not fixed but arise spontaneously out of the ever-changing interaction between the flow of input to the net, the relatively static memory traces, and the net's flowing attunement. It is not that something is being done to something—not that logical operations are applied to representations—but instead there is an interaction of the various participations in the whole. In such participatory holistic cooperation and autodynamic movement, the character of computation as driven, mechanical information processing is lost.

5. The noncomputational process of differing and deferring

The computational process is one of rule-governed transformations of symbolic representations. The noncomputational process described here is one of differing and deferring. (In another context, that of texts and writing, Derrida calls this *différance*. See Chapter Three, Part II.)

Given a net with uniform connectivity, connection weights, transfer functions and parameters, the topography of hyperspace is undifferentiated. Difference appears when the connectivity, weights, transfer functions and parameters are tuned by input, learning and/or self-tuning. Differing is especially

striking in the fluctuations of hyperspace topology. This process is not a transformation of representations but an incessant and spontaneous differing of itself from itself. There is no launch-point, no center, no end, in the spontaneous play of differing (to make a Derridean point).

Deferring is very much a Freudian concept (Freud, 1900/1953, chapter seven), whereas differing is Saussurian. Freud distinguished between the "primary process" that proceeds directly to the pleasure of instinctual gratification and the "secondary process" that delays drive satisfaction under the reality principle, so that a "detour" is taken to gratification via thought. In state space terms, the attractor is the memory of the instinctual object. Under the primary process, the trajectory goes downhill directly to the instinctual attractor. Under the secondary process, the trajectory is made to defer settling into the attractor. The deferral is accomplished by tuning of the net; the local topography is adjusted so the trajectory takes a detour from what would otherwise be the most direct path. Deferring breaches the paths of difference. In the case where the instinctual attractor is forbidden (e.g., Freud's "incestuous object"), a permanent and unbreachable barrier is maintained around the attractor; this is called the "defense" that is continually sustained by the so-called "countercathectic energies," which are reinterpreted here as self-tuning.

So the noncomputational process continually differs from itself and defers its attractors, in a spontaneous and unpredictable self-organizing process under tunable constraints—which is anything but the strict and necessary march of the computational process.

6. The whole is the tuner

The question might be asked: Who or what does the inner tuning in this account? If self-tuning requires a tuner, something higher—a *homunculus* or *Demiurge* who keeps tweaking the net, a ghostly subject that goes by the name "I"—then the theory will hardly do.

To answer this question, an understanding of "hierarchy" in neural net terms is required. Thus far network nodes were conceived of as formal neurons organized into "hyperneurons." Now suppose that these self-organizing hyperneuronal networks are themselves nodes in a "higher" net, and that this nesting recurs for many iterations. (See Figure 4.2.) At the highest level, these nodes would be of great complexity; at this level they could be described as self-organizing "modules" that are nodes of a *supernet*. These modules variously activate, inhibit, and tune each other as they drop in and out of participation in the whole supernet, which flowingly evolves. The supernet state of attunement arises spontaneously out of the whole.

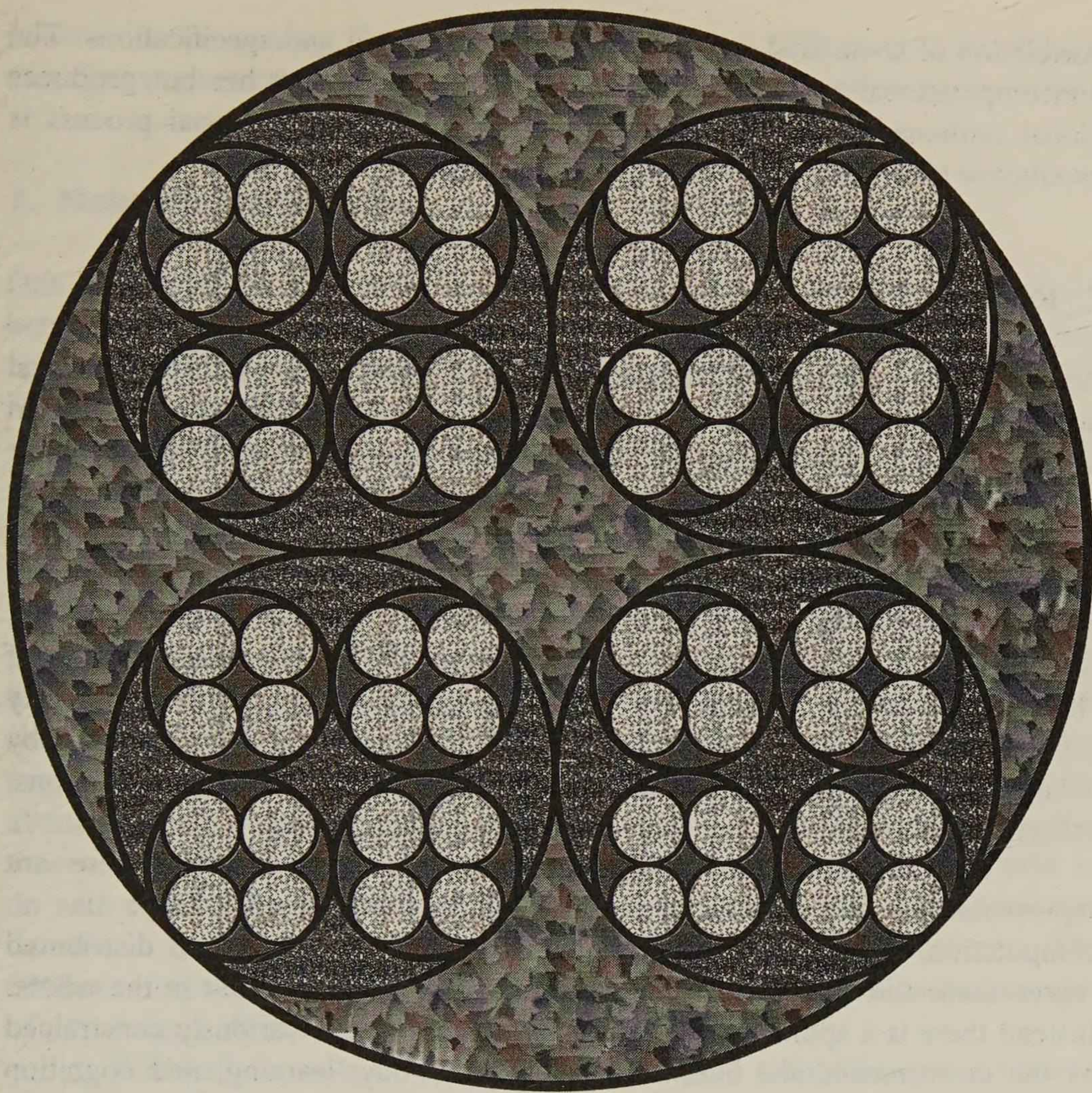

Figure 4.2: Recursive Organization. Four circles are nested through three recursions in the illustration.

So "what" does the tuning is nonlocal; the "self" is holistic. This nonlocal self is not higher but has wider participation and, thus, increased complexity. The fluctuating attunement intersects with samples of the surround, and the whole net evolves along its unpredictably bifurcating path through state space.[11*]

This noncomputational process should also be distinguished from condition/action mechanisms which are computational. The rules of condition/action give conditions of satisfaction and when the re-presentation of input meets those conditions, a certain action is taken (perhaps a recognition signal, recall of a memory or search for another input). For condition/action, instead of the rules transforming representations, the rules *specify* representations that satisfy the conditions, and the computation calculates a

correlation of some kind, i.e., the match between input and specifications. The noncomputational process, in contrast, does not detect matches but produces global settlements under tuned constraints. The noncomputational process is *productive* (not selective, as Edelman would have it).

7. Review

According to conventional connectionism, information flows through neural nets. The re-presentation of input is processed in distributed form in the hidden layers. Indeed, "hidden" layers is an easily misunderstood expression. It is true that there is an input layer in which the impinging stimulus information is re-presented in network terms—transduction is accomplished—and an output layer in which a transformed re-presentation appears that commands output; input and output layers are superficial and mask the "hidden" layers within, where distributed processing occurs. But also the re-presentation is itself "hidden" within the hidden layer, distributed, "subsymbolic," as Smolensky (1988) says. Where conventional connectionism expands on the tradition is by enlarging the notion of representation to include distributed representations; otherwise conventional connectionism remains computational.

What I have called "radical connectionism" denies that there are representations altogether, whether local or distributed. There is no computation. Something very different is going on. There is no distributed representation in this account that is processed while it hides out in the whole. Instead there is a spontaneous, dynamical process that is variously constrained by the environment, the internal milieu of the body, learning, and cognition (understood as holistic self-tuning). The system of networks evolves under all these and other (e.g., linguistic) constraints. Information of the world is not re-presented in the nets and processed but a world-derived constraint participates in the whole with other constraints, enfolded to a whole self-organizing process.

The equations that best capture these nets apply to the evolution of nonlinear dynamical systems, which are prone to deterministic chaos. The evolution of such equations can be thought of as a trajectory in a high-dimensional state space or hyperspace that is studded with attractors and repellers. These prominent features in the state space topology are not static, as we have seen, but fluctuate with self-tuning; in effect, the network self-tuning is biased for certain attractors as the net intersects its input flux. Both the surround and the body are in flux, and the network attunement is also in flux; out of their mutual participation and settlements a trajectory evolves. At the superlevel of the recursively organized neural system, the settlements in the trajectory comprise the stream of consciousness. Such participatory, unpredictably harmonizing self-evolution is not easily conceived of as

information processing; there is a scientific paradigm difference at work here that opens toward the possibility of a noncomputational cognitive neuroscience.

8. Molecular "information"

One of the launch points for the present discussion is the great discrepancy between the silicon simulations of bench connectionism and the actual living neural case.[12] Black, in addition, goes on to elaborate a theory of molecular information processing that far transcends silicon implementation and is grounded in the achievements of neuroscience. Since Black's molecular computationalism and the present noncomputationalism diverge sharply from an initial point of critical agreement about simplified nets, a comparison is instructive.

It is easy to forget that "information in the brain," even in "a molecular perspective," is a theory. (The quotes are the title and subtitle of Black's 1991 book.) The neuroscientist deals operationally in the physical measurement of chemicals, electrical spikes, and the like. The idea that molecular mechanisms might "receive, transduce, encode, store, retrieve, and express information about the real world" (p. 14), however, is purely theoretical. An alternative theory is that the readings on the neuroscientist's measurement devices have to do with *influencing and being influenced*, i.e. with *participation* in a nonlinear dynamical system that is self-organizing, self-tuning, and autodynamic. The difference between these theories is so fundamental that we can properly speak of a "paradigm difference."

We shall consider this paradigm difference in a specific case discussed by Black in the section "Communicative symbols and transducer molecules" (p. 55). Black begins with the claim that "certain molecules within the nervous system are capable of acting as transducers, converting one form of information to another." (p.55) My alternative theory is that *information is converted to constraints on a process*.

At other places, however, the two theories come close together.

> Specific communicative symbolic molecules convert environmental or internal information into altered neural function and behavior. (Black, 1991, p.60)

Here *information is converted to altered function.* The present noncomputational theory agrees, interpreting "altered function" to mean "the tuning of constraints on a self-organizing process." With regard to the information-to-behavior conversion, the two theories completely agree. Here the issue is the conversion of an input vector to an output vector. But how that

is accomplished within the "black box" and whether that performance has anything to do with information, ought to be an open question.

"Neurotransmitters...are quintessential communicative symbols in the nervous system" (p.55). Again, Black's idea that there is communication going on is theoretical; my alternative theory is that a process is influenced by neurotransmitters. The notion of "symbols" is also theoretical.

> Although their [neurotransmitters'] communicative functions have long been apparent, their symbolic functions have not been recognized. Yet these molecular signals are known to change in highly specific ways in response to environmental events. (Black, 1991, p. 55)

Here Black distinguishes the communication of information between neural systems from the "symbolic" *representation* of the world. He is surprised that the symbolic function has not been recognized because the molecules change specifically in response to environmental events. But a covariation between environmental events and molecules does not necessarily imply that the molecules symbolically represent the environment. It is equally possible that the molecules are *influenced* by the environment and these influenced molecules *participate* in the self-organizing dynamical process. Again, this statement is made:

> Neural structures that are regulated by specific environmental stimuli, that change function in response to those stimuli, may represent those external stimuli in the nervous system. (Black, 1991, p. 45)

Here there is slippage from "regulation" to "representation," whereas we can alternatively think of regulation as tuning of a process.

Another specific case discussed by Black (chapter 8) is disconnexion syndromes (Geschwind 1965). At the most complex levels of brain functioning, there are functional modules that inter*communicate*. When the communication is severed—in the extreme case, right and left brains do not directly communicate—peculiar syndromes result. For example, even though a patient may have normal hearing, reading and writing, the spoken word cannot be understood when Wernicke's area is severed from auditory input. (p.139) Tactile aphasia occurs when Wernicke's area is severed from somesthetic sensory input, and disconnection of Wernicke's area from motor centers results in an inability to execute commands (apraxia). In disconnexion syndrome the lesion blocks communication, according to Black.

But disconnected "communication" has at least two interpretations here. In Black's, what is communicated to the module housed in Wernicke's area is information, a message. When Wernicke's area is cut off from auditory

information, for example, the Wernicke's module is unable to compute the meaning of spoken words, unable to process the auditory information, even though hearing, dependent on other modules, is intact. The written word, however, "communicates" with Wernicke's module through intact visual pathways, and the written word is meaningful.

An alternative interpretation is that Wernicke's area is a complex node whose settlements provide the meaning of spoken and written words. The Wernicke's node is tuned by auditory and visual inputs (among others) and is constrained accordingly in its self-organizing process. When the changing auditory influence is disrupted in disconnexion syndrome, the settlements become free of constraint in this regard, while the influence of particular written words on the Wernickian self-organizing process continues to constrain the settlement process toward certain attractors.

Despite the information processing emphasis, a dynamical model peeks through at various places in Black's presentation.

> ...the neuron and the synapse are emerging as unexpectedly dynamic entities that change from millisecond to millisecond... Indeed conceptions of the very nature of neural information are undergoing marked changes. (p. xii)

> Extensive evidence indicates that the brain is not an immutable series of circuits of invariant elements; rather it is in constant structural and functional flux. The digital computer analogy is fatally misleading. (p.3)

There is no place to stand in such a dynamical evolution—no origin (*arche*), no end (*telos*), no center (echoing Derrida [1974]), only a dynamical interplay.

> Environmental stimulus, mental state, behavior, and molecular mechanism are in constant interplay... (Black, 1991, p. 167)

And Black closes his book with this trenchant statement:

> The essence of life systems may involve the central fact that high levels continually transform the lower, elemental levels upon which the high levels are based. Appreciation, description, and analysis of this ubiquitous phenomenon may represent one of the fundamental tasks of the life sciences. (p. 181)

When the higher transforms the lower that transforms the higher, there is no ground or center or foundation. Black's statement can be construed as a roundabout description of the spontaneous and unpredictable holistic evolution of recursively organized, nonlinear dynamical systems.

That a tacit dynamical conception underlies Black's information processing approach is also apparent in his blurring of the distinction between "hardware" and "software."

> ...the brain can no longer be regarded as the hardware underlying the separate software of the mind. Scrutiny will indicate that these categories are ill framed and that hardware and software are one in the nervous system. (Black, 1991, p.xiii)

> ...the molecules, the transformations of biochemistry, and the principles obeyed are both hardware and software. These terms, however, fail to capture the nature of neurologic function. (Black, 1991, p.5)

But information processing is a computation that depends on structure-sensitive *rules* (program, software) acting on hardware *representations*. Since the distinction between rules and representations is not maintained when "hardware and software are one," there is no basis for speaking of information processing. Furthermore, there are various mechanisms "by which the molecular structure, the 'hardware,' of neurons changes over time, altering function" (p.7). There is nothing comparable to this in computation; the hardware is "hard" precisely in its invariance, in contrast to the soft changeable program.

So even when we turn from the impoverished silicon neurobiology implementable at the bench to the rich neurobiology displayed by Black (1991), information processing remains theoretical and an alternative theory of evolving nonlinear dynamical neural systems is conceivable, against the tradition.

9. Cognitive "information"

At the cognitive level, too, well-established empirical data support alternative computational and noncomputational interpretations. Baars' Global Workspace Theory of consciousness is a computational theory with which the present noncomputational theory can be fruitfully compared. Following a contrastive method, Baars summarizes the capabilities of conscious processes and unconscious processors on the basis of the research literature.

Baars' Global Workspace Theory of brain functioning posits a global workspace in which specialized processors *may* participate. When specialized processors do not participate, they continue functioning in parallel, each processing the information that comes to it in an independent fashion. But when participating in the global workspace, specialized processors gain access to global messages and can send global messages. The emerging dominant message among competing messages is the content of consciousness. Table 4.1

of conscious and unconscious processes (Baars, 1988, p.75) can be explained in accordance with Baars' Global Workspace Theory as follows.

Nonparticipating processors are adapted to the messages they receive and so the computations proceed very efficiently and in parallel, without regard for inconsistency between them. Participating processors are subject to the emergence of a dominant message, which takes time and all the resources of the global workspace. Participating processors are doomed to seriality and a consistent product in virtue of participation in a global process of cooperative and competitive communication. But the gain for participating processors is flexibility through the information exchange via the global workspace. Through participation, processors get into the information loop and have a voice in the process that produces a dominant global message, which is the conscious content.

Table 4.1. Capabilities of comparable conscious and unconscious processes (Baars, 1988, p.75)

Capabilities of conscious processes	Capabilities of unconscious processes
1. Computationally inefficient: High number of errors, low speed, and mutual interference between conscious computations	1. Highly efficient in their own tasks: Low number of errors, high speed, and little mutual interference
2. Great range of different contents over time: great ability to relate different conscious contents to each other; great ability to relate conscious events to their unconscious contexts	2. Each specialized processor has limited range over time: each one is relatively isolated and autonomous
3. Have internal consistency, seriality, and limited capacity	3. Diverse, can operate in parallel, and together have great capacity

Baars summarizes:

> In conclusion, we can now replace all of the facts described [in the table] with a rather simple model: the idea of a set of specialized processors, each well equipped to handle its own special job; all the specialists can communicate with the others through a global workspace. In this way they can cooperate and compete with each other, to strengthen or weaken a global message.

> Like consciousness itself, this system works best when routine tasks are directly delegated to the best expert that is ready to solve it, and the use of the blackboard [workspace] is reserved for just those problems that cannot be solved by any expert acting alone. When the cooperating processors discover a single algorithm able to solve the problem, that algorithm can again be handled by a single expert, freeing up limited global capacity for other unsolved problems. (Baars, 1988, p.92, brackets added)

But the same data are consistent with the noncomputational model and its metaphors.

In the noncomputational framework, participation does not mean getting into the information loop with its global blackboard and its competing or cooperating messages. Participation instead means both constraining by influencing a spontaneous, global, dynamical process and being constrained by that global process. The process proceeds within the context of an attunement. Nonparticipating processors are settled into solutions that well adapt them to their input. These mutually inconsistent processors proceed in parallel and with great joint capacity. Participating processors are subject to the self-organizing process of the global whole, which produces consistent serial settlements that utilize total capacity. Global participation of many processors in the self-organizing process insures flexibility, a wide range of potential settlements, and, because of the stochastic nature of the process, a quirky unpredictability.

In comparing the computational and noncomputational models, we again find empirical data nondiscriminating. The computational inefficiency of consciousness, the great range of its contents, its self-consistency, seriality and limited capacity—as well as the opposite properties of unconscious processes—can all be explained by either the theory that information is being processed by a brain with a global information exchange or by the theory that an unpredictable, self-organizing, dynamical process is spontaneously generated by an evolving brain process whose constraints are continually tuned. At levels of complexity from the neuronal node of the hyperneuron to the supernet whose nodes are highly complex self-organizing modules, Baars' theory envisions the processing of information while my theory envisions influence on a self-generating, self-organizing, self-tuning, dynamical evolution.

10. The fractal geometry of state hyperspace

Thus far the emphasis has been on the computational and noncomputational models as *alternative* explanations. The focus now shifts to choosing between them, by considering the geometry of state hyperspace. Let's first consider a classical dynamical system.

The state hyperspace attractors for classical systems are typically in the form of points, limit cycles and tori. Classical systems that follow dynamical equations are, in principle, predictable (e.g., as with the prediction of eclipses). Suppose one narrows the initial state of the classical system to a small region of hyperspace. (Because of unavoidable small measurement errors, we cannot be certain of the exact point.) Knowing the initial state and the evolution equation, it is possible to predict the final state within a small region of hyperspace. This predictability is consistent with the idea of computation. But nonlinear dynamical systems are nonclassical and unpredictable, like the weather, as Lorenz has shown.

For even very simple nonlinear dynamical systems with only a limited number of variables, the attractor can be chaotic and the geometry "strange" in that state hyperspace for such systems has a fractal dimension. Any uncertainty about the location of an initial state is exponentially amplified so that the final state is unpredictable in principle. Nearby trajectories diverge exponentially rather than remaining confined to a small region of state space.

> Thus the initial uncertainty in the specification of the system is eventually smeared out over the entire attractor and all predictive power is lost, i.e., all causal connection between the present and the future is lost. This is referred to as sensitive dependence on initial conditions. (West, 1990, p. 13)

This uncertainty is "fundamental to the system dynamics and gathering more information will not reduce the degree of uncertainty" (p.8).

The rate of divergence of initially nearby trajectories in dynamical systems manifesting chaos can be quantified by means of Liapunov exponents and the rate at which the system becomes unpredictable can be quantified by the Kolmogorov entropy.[13] These quantities have been calculated for EEG time series, and, as we shall see in the next section, appear to increase from coma and NREM sleep to waking.[14] In any case, the difference between computational and noncomputational models can be well-posed, for the hyperspace geometry of the latter has a fractal dimension.[15]

Computation, as understood by the tradition, is not performed by chaotic systems. Computer computation is not sensitively dependent on initial conditions. Small fluctuations in digital components do not effect the result of silicon information processing. A system which, in principle, gives unpredictable results is not computing. *So if it could be empirically demonstrated that brain functioning shows sensitive dependence on initial conditions, then the brain is not computing, at least in the strong sense of performing information processing.* And if the brain does show sensitive dependence on initial conditions as revealed by fractal properties, then this opens toward a new

paradigm in which the brain evolves as an autodynamic, self-tuning, nonlinear dynamical, complex system under tunable neurochemical constraint.

11. Evidence for fractal properties of the nervous system

West's helpful discussion of fractal physiology and chaos in medicine discusses the three "guises" of the fractal concept. In the first guise, the fractal is geometric. Here the complexity of ramifications in a tree-like structure is conserved with increasing number of branchings; the pattern of branchings remains self-similar as one goes further and further out the tree. West reviews evidence that the bronchial tree and the His-Purkinje network of the heart are self-similar (fractal) in their arborizations; that is, as the bronchial tree and the His-Purkinje networks become more finely ramified, the complexity remains. (If these anatomical structures were non-fractal, they would *simplify* to primitive irreducible elements or to a continuum.) The bushier the tree, the higher the fractal dimension. The possibility that dendrites, too, form a branching tree with fractal properties has been investigated by Morigiwa, Tauchi and Fukuda and by Schierwagen.

If the arborization of neural processes, both dendritic and axonic, turns out to be geometrically fractal, then this is of great functional importance. As already noted, the spike initiated at the axon hillock can be recorded at only a few tenths of the presynaptic terminals (Shepherd, 1986) and the extent of penetration of the initiated spike into the arborization is controlled by both the neurochemically modulated shape (Westerfield, Joyner and Moore, 1978) and frequency (Luscher and Shiner, 1990) of the action potential. Thus, functionally speaking, fractal geometric properties may be neurochemically tuned.

Another guise of fractals is statistical self-similarity with magnification. In a fractal stochastic process, according to West, not only does the process itself display a kind of self-similarity, but so too does the distribution function that characterizes the statistics of the process (p.77). Teich et al. have presented a relevant study of sequences of action potentials recorded from adult-cat auditory nerve fibers and lateral superior olivary units. They report that the firing rate remains self-similar when calculated with different averaging times and further that the cluster distribution remains self-similar. These neurons thus show statistical fractal properties.

The third guise of fractals discussed by West has to do with time series. (See also Teich, 1992.) For a recent example, Canavier, Clark and Byrne have modeled the R15 bursting cell in the abdominal ganglion of *Aplysia*. The model exhibits both bursting and beating modes. But there is also a chaotic regime with a calculable fractal dimension between these two modes. Rapp et al. studied the interspike intervals of spontaneously active neurons in the simian

motor cortex and concluded that, at least on occasion, the neuronal activity is chaotic. Furthermore, the chaotic behavior of certain neurons had a low fractal dimension, indicating comparatively simple dynamical behavior (i.e., few degrees of freedom are required in the dynamical law that specifies the neuron's behavior).[16] Mpitsos et al. have provided evidence that some of the variability in the spike trains of motor neurons of the mollusc *Pleurobranchaea californica* can be attributed to chaotic activity.

Furthermore, there is some reason to think that cognitive functioning correlates with the "correlation dimension" of the EEG.[17] West concludes that "the dimension of the 'cognitive attractor' [underlying the EEG] decreases monotonically as a subject changes from quiet, awake and eyes open to deeper stages of sleep" (p. 19). Functionally speaking, the hypothesis is that the dynamical behavior of the EEG grows more complex with cognitive activity.[18] This is a plausible hypothesis that invites further experimental investigation. Furthermore, there are preliminary reports that level of cognitive activity varies with the degree of chaos as measured by Liapunov exponents and Kolmogorov entropy.[19]

Although we are far from being able to speak confidently of a "fractal brain," there are, at least, the beginnings of an experimental and modeling literature suggesting that nervous tissue has fractal geometrical, statistical and dynamical properties and that there may be fractal correlates of cognitive activity. This literature is consistent with the noncomputational theory and inconsistent with the computational theory because the sensitive dependence on initial conditions for a state hyperspace with a fractal dimension spreads a principled uncertainty consistent with the noncomputational, but antithetical to the computational, theory. Since cognitive neuroscience produces a wide range of time series data, there is opportunity to distinguish what appears to be noise from what may turn out to be deterministic chaos. Reports that fractal properties of the EEG vary with level of cognitive activity are especially intriguing and call for further study. Despite the present indiscernability of computational and noncomputational theories with respect to much available data, research on the hypothesized fractal brain properties should prove decisive.

APPENDIX

The Binding Problem

The concept of participation permits a solution to the "binding problem": since the brain segregates neural processing streams, it has to "bind" bits and pieces in widely separated regions into an integrated whole.

> If parts of the representation of an entity are distributed over distant regions of the brain, then mechanisms must be available to bind together the fragments. (Damasio, 1989, p. 127)

The classical solution to the binding problem is that all the parcellations of information are confluent in "multimodal cortices" where the integration occurs, but Damasio (1989, Damasio and Damasio, 1994) reviews experimental evidence that shows this view to be untenable. This solution reeks of metaphysics: parts are composited into the whole.

Damasio offers an interesting alternative. His idea is essentially that there are "convergence zones" on which widely scattered information fans in and from which information fans out widely. The fan-out comprises "binding codes," which are "combinatorial arrangements" for the scattered information; fan-outs "describe...pertinent linkages in entities and in events" (p. 129). In effect, the patterns of neural activity in multiple separate regions are programmed by the convergence zones into compositions. (For the classical view, projections of the multiple regions overlap in multimodal cortices.) These disparate regions become "phase-locked" and achieve coherence through programming by the binding codes.

Damasio's proposal shows a more sophisticated metaphysics. There are still parts structured into a whole, as in the classical view, but, in addition, rules of combination are provided by the convergence zones. In effect, Damasio saves metaphysics from the empirical findings that show there is no one area where the separate information is bound together, by saying that there are multiple zones where information converges and from which binding codes are emitted to multiple areas, which accordingly become integrated.

My proposal is that multiple brain areas are bound together by participation in the whole. Participation in the whole is fundamentally unlike parts combined into a whole (like strings of symbols), for in participation the parts interpenetrate. Such a whole has global properties. For this global solution, which is no longer metaphysical, the "binding problem" disappears, since in participation there are no longer any parts to be bound. Given

participation of subsystems in a recursively organized central nervous system, the subsystems interpenetrate in the whole.

CHAPTER FIVE

PSYCHIATRY AND THE NEW DYNAMICS

A nonlinear dynamical view of brain functioning was developed in chapter four, in the context of cognitive science. In the present chapter this view is applied to the clinical science of psychiatry, and, in turn, the nonlinear dynamical conception is more clearly exposed by the application. Readers who have mastered chapter four can skim parts of Section 1, which redevelops that material while interpolating new material..

Cognitive science, like neurochemistry, can be one of the basic sciences in psychiatry, although it has been largely neglected in that field. Psychiatry deals with "mental disorders," and cognitive science is the science of the mind, so developments in cognitive science have great significance for psychiatry. Callaway points out that such science provides important linking variables.

> The connectionist models and cognitive models of modern psychology together can provide us with more useful links between neurophysiology and phenomenology. The connectionist or parallel distributed processing (PDP) neural net models link neurophysiology and cognitive psychology, and cognitive psychology in turn provides the link to the phenomenology of the clinician. (Callaway, 1992, p.1).

The interface between nonlinear dynamical cognitive science and psychiatry will be explored here.

Nonlinear dynamics offers a revolutionary framework for psychiatric thinking, which until now has readily adopted information processing conceptions. (Even psychoanalysis has assimilated computation.[1]) Skarda and Freeman[2] state that the new dynamics has a "revolutionary impact...on our model of cortical functioning and on our understanding of neuroscientific explanation," and provides "powerful new concepts for analyzing and interpreting data," while Abraham[3] considers nonlinear dynamics to be "a world view as well as an elegantly simple modeling strategy" which is "emerging as the metalanguage, the *metaparadigm*, of science." Early on, Mandell[4] discussed nonlinear dynamics in brain processes and saw that "the present era of qualitative mathematical description of the behavior of complex and dense systems promises a language for a scientifically based attempt at the fusion of clinical psychiatric phenomenology and neurobiological mechanism." The

potential importance of nonlinear dynamics for psychiatry has been emphasized by Freeman who states, "As the science of change with time, dynamics is the essence of psychiatry."[5] Applications of neural networks and nonlinear dynamics to psychiatry have appeared, including discussions of schizophrenia and related phenomena,[6] manic-depressive disease,[7] anorexia nervosa,[8] dissociative disorders,[9] panic disorder[10] and hysterical and compulsive personality.[11]

Section 1 of this chapter presents the nonlinear dynamical framework. Using this framework is an important step in understanding the complex systems that psychiatry encounters. In a linear framework, change is proportional to input; therefore, a large change in output will require a proportionally larger input than a small change. Within a nonlinear framework, however, very small inputs can cause large changes in output. (This is consistent with clinical observations that seemingly insignificant statements made by the therapist can have a dramatic effect on a patient's behavior.) From this nonlinear framework, specific models that make testable predictions can be derived. Paraphrasing Freeman's[5] comment on models, frameworks are not true or false, merely useful or misleading, and they do not prove things but interrelate them.

Section 2 presents applications of this framework to psychiatry and a discussion of a specific predictive model. First biological psychiatry is conceptualized within the framework of nonlinear dynamics. Second, a beginning attempt is made to put the classification of mental disorders in terms of state space, which provides an intuitively clear geometric representation of the classification of mental disorders ("nosology"). This offers a unifying framework for what is presently a rather heterologous group of mental disorders. In the final application, schizophrenic phenomena are explained in terms of the model.

1. The new dynamics of the brain

The consensus view since mid-century has been that the brain is a "wet computer" that processes information by performing computation on symbolic representations.[12] This idea that the brain processes information is extremely pervasive; great effort is required to appreciate alternative formulations.

According to the new dynamics, the neural networks of the brain belong to the class of nonlinear dynamical systems. The mathematical theory here relates to coupled integrodifferential equations, topology, and fractals, which is nothing close to the digital (Boolean) logic of computers. Such systems spontaneously evolve. They are subject to sudden and unpredictable bifurcations to new and markedly different states in which increased complexity

is shown, comparable to Prigogine's dissipative systems at far-from-equilibrium conditions.[13*]

A powerful representation used by the new dynamics is provided by the state space whose points represent all possible states of the dynamical system.[14] (See Figure 4.1, p. 69.) This space is typically multi-dimensional, a *hyperspace*. (Hyperspace cannot be visualized, and it is misleading to do so; hyperspace is a mathematical "space." The space illustrated in Figure 4.1 is a ladder that must be thrown away when a certain level of understanding has been attained.) Each system variable is represented by a dimension of the hyperspace. The state is defined as the value of each system variable at some time, t. So the state of the system at t can be represented as a point in hyperspace. In the case of the hyperspace representation of neural networks, the output value (activation) for each neuron of the net can be given a dimension: N neurons, N dimensions. Thus the state of the neural system (the values of the N neuronal outputs) is represented as a point in an N-dimensional hyperspace and the system's evolution over time follows a trajectory or flow in hyperspace.

A key concept in gaining intuitions is the concept of the topology of the state space. As an example, consider a three-neuron system. The activity level of the neurons give the state of the system. Every point in the three-dimensional space representing this system would correspond to a state defined as an activity level for each of the neurons. Furthermore, each point in the three-dimensional space would have an "energy" level associated with it that determines how much of an attractor the state is. (Due to the interconnections of the neurons, as well as any external electrical fields, certain levels of activity of the three neurons, i.e., certain states, will be more probable than others.)

Picture the attraction of a state as being represented by a color, with pure blue having the stongest attraction and pure red having the least attraction. This will then associate every point in the three dimensional state space with a color on a blue-red dimension corresponding to that point's "energy." The topology of the state space then is represented by the color patterns in the space. (Note that in Figure 4.1, p. 69, the energy topology is represented on the vertical dimension, whereas here it is represented by the color of the points. These representations are quite arbitrary and serve as aids to the intuition, which must extend nonvisually to hyperspace.) The system will avoid the red areas and move in the blue areas, which correspond to the attractor subspaces for that three neuron system. Attractors do not necessarily occupy points in hyperspace but may, for example, have circular or toroidal (doughnut-like) shapes around which the trajectory cycles.

As has been emphasized, the constraints on the dynamical system influence the topology and, therefore, steer the system's trajectory. The topological characteristics of this surface will determine the most probable states toward which the system will move and in which it will remain, viz., the

attractor states. One powerful form of constraint is the strength of synaptic interconnections ("connection weights") between neurons which controls how much influence gets through. Changes in these synaptic connections as a result of learning, while local in nature, can still alter the topology; the position of peaks and basins is shifted, thereby causing new attractor states to appear. This causes large scale changes in network functioning.

The changed connection weights comprise the memory trace. The memory that is retrieved has not been stored as such; a constraint is stored in the connection weights, and in retrieval the recovered memory settles out. Well-learned states are powerful attractors for trajectories in the vicinity; these states have wide "basins of attraction."

Another form of constraint is the input/output transfer function at each neuron. External input to the system also constrains it. So we can think of the dynamical system as evolving under a variety of constraints along a trajectory through hyperspace. The topology shifts and the trajectory accordingly changes as the input, connection weights and transfer functions change. A variety of system variables—such as noise, the ratio of excitation to inhibition, and the temporal decay parameter for existing states—also affect the trajectory. Examples of more general constraints include the brain's maturational state, drug effects, and metabolic conditions.

Given initial conditions of the system and the constraints, there are certain states—the attractors—that are more probable, and, once realized, tend to be stable. Improbable, unstable states are "repellers." Attractors are those states that best satisfy the multiple constraints: *attractor states optimize multiple constraint satisfaction*. The hyperspace topology shows the degree of satisfaction. Thus, simple point attractors lie in N-dimensional basins, whereas point repellers perch on N-dimensional peaks. More complex attractors are spread over wide regions of hyperspace; here the "settled" system keeps changing state but remains confined to the finite attractor. The spontaneous tendency of the system is to follow a trajectory that moves downhill and settles into an attractor of the hyperspace, until conditions are altered, the topology shifts, and the attractors change.

In addition to the constraints already mentioned, there is moment-to-moment modulation of constraints, called *tuning*. To appreciate the concept of tuning, which is crucial to the new paradigm, we must grasp the model more clearly.

The currency of the nervous system is produced by the interactions between neurons; the mass of interactions via the connectivity is what the nervous system has to work with. It is *constraints* on the interactions that bring about difference in the otherwise undifferentiated mass of neuronal interactions. Examples of constraints are synaptic efficacy, the input-output transfer function of the neuron, and the type of neurotransmitter expressed. Constraints may be

relatively fixed—by the genes or by learning that modifies synaptic efficacy—or constraints may freely change, be *tunable*, as when a neuron releases a classical transmitter at low frequencies of stimulation or releases a neuropeptide at high frequencies. The type of neurochemical released into the synapse is a powerful constraint on the interactions between neurons; this is a tunable constraint that leaves no trace. Tunable constraints permit fluid differences to arise in the mass of neuronal interaction already differentiated by the fixed constraints.

Tuning of constraints molds the topology of hyperspace and changes the state probabilities. The brain is a *self-tuning*, dynamical system. Self-tuning is not a program; there are no rules involved. Self-tuning modulates constraints. Nor are constraints programs of rules. Constraints variously contribute to the shaping of the evolution of the dynamical system as it spontaneously and unpredictably self-organizes. Nor is there any implication that a Cartesian subject—a "ghost in the machine"—functions as the tuner. The brain is constructed so as to tune its own constraints as it intersects with input from the environment. In virtue of tuning its own constraints, the brain exerts a measure of self-control.

There are a variety of sources of tuning. For example, drives are powerful tuning sources. In the present framework, "motivational states" are no longer particular behaviors or dispositions to behave but *global attunements* of the brain. When we are hungry, our neural nets are tuned to perceive food, think about it and act to attain it. Similarly, "emotional states" are not behaviors or behavioral dispositions but brain attunements. So when we are elated, our global attunement is such that we perceive the world "through rose-colored glasses," think optimistically and become energetic. Again, cognitive states are conceived to be brain attunements. A plan to achieve a goal is not a prescription for a sequence of behaviors but is a global constraint that affects perceiving, thinking and action. Attractors of the resulting topologies are associated with goal attainment. Thus motivation, affection, and cognition imply tuning of constraints that result in global brain attunements that powerfully, but not exclusively, influence behaviors.

The brain is other-tuned as well as self-tuning; that is, sensory input is also a source of tuning. The freeway traffic gets heavy, and we become attuned to drive more carefully. Someone says, "There are lots of rattlesnakes around here!" and we become immediately attuned so that a curved stick lying on the ground looks like a snake; we are constrained toward perceiving rattlesnakes so that in the presence of an ambiguous stimulus (the curved stick), a snake perception settles out.

As the brain tunes itself while intersecting an input flux, hyperspace topology fluctuates. The fluctuation continues even when input is held constant, so long as self-tuning is in operation. A state that lies in a basin may, after self-tuning, lie on a peak and accordingly start to evolve downhill. Self-tuning thus

gives the brain an autodynamic property; by tuning itself, the brain produces its own movement. Thus the brain is *autorhoetic*, promoting its own flow.

Another crucial feature of state hyperspace represents the tendency of neural nets to settle into *chaotic attractors*, where the nets' behavior appears to be random even though it is in fact deterministic. Chaotic attractors are spread within the hyperspace and have a variety of shapes. These attractors are designated "strange" and have a *fractal dimension*, i.e., are self-similar at increasingly higher levels of magnification. Because of the "sensitive dependence on initial conditions" shown by chaotic systems, long-term prediction of future states cannot be done accurately, even though the evolution of states is deterministic and predictable in the short term.[15] ("Sensitive dependence on initial conditions" means that small errors in measuring initial state, and even uncertainties in measurement at the quantum level, expand exponentially over time so that the future becomes unpredictable in principle [Schuster, 1988].) A system in a certain initial state may evolve under a chaotic regime to a state anywhere on the spread-out strange attractor. This fractal feature of the state space representation has preliminary empirical support in evidence that the EEG is chaotic,[16] that EEG chaos increases with increased cognitive activity,[17] and that the firing of individual neurons is chaotic.[18] While the evidence for chaos in the EEG is not conclusive, it is clear that the dimensional complexity of the EEG does change with mental states. The full representation of the dynamically conceived brain states utilizes a hyperspace with a topology and a fractal dimension.

It is crucial to appreciate that such dynamical neural nets are *self-organizing*. The nets are not "programmed" to follow serially applied rules. Computers are other-organized by the programmer, whereas dynamical nets spontaneously self-organize toward a consensus state that well-satisfies the constraints discussed above. There may be many states that well-satisfy the constraints, each with its own relatively high probability. The net self-organizes unpredictably into one of them.

Another important feature of neural nets is their *recursive organization*.[19*] A network of neurons can be called a *hyperneuron*. Here the functional unit on which input fans in and from which output fans out—the "node" where connections are made—is a neuron. But the hyperneuron may be a node in a more complex self-organizing net that, in turn, may be a node in still a more complex net, as Alexander has discussed. At the most complex "supernet" level, the nodes are themselves highly complex self-organizing systems. This nested property is called "recursion." (See Figure 4.2, p. 72.)

It should be noted that the supernet is not Sherringtonian, not a "higher" system controlling "lower" systems but something more complex, encompassing wider participation because of interconnections between richly nested nodes. (The traditional idea that higher controls lower is very well

entrenched in our thought.) Recursion of the brain networks is further complicated in that participation of self-organizing systems in the supernet is not obligatory but fluidly changes. (Compare my discussion with Baars' discussion of variable participation in an information processing framework. See pages 76-78.) Not all systems participate all of the time. Non-participating systems continue to operate independently in parallel. According to the present view, *the changing states of the dynamical supernet with its varying dynamical participants correlates with the changing states of consciousness.* The flow of the supernet trajectory in hyperspace represents the stream of consciousness. Subsystems that do not participate at a given time are not conscious, but they continue to evolve independently in parallel.

Whether or not a subsystem participates depends on at least two factors: input and attention. (Again compare my discussion with Baars' formulation.) First, the subsystem is set to resonate to a certain kind of input. When input is outside the range, the subsystem is unresponsive, and does not participate in the supersystem. Input that falls within range elicits a subsystem response and participation, but as the subsystem adapts to its input and reaches a point of resonant harmony, participation fades. Classical "habituation" is thus reinterpreted as departicipation. Second, when attention is directed, say in listening, then the subsystem that subserves hearing participates, even when input is outside range or habituation has taken place. Thus *attention*, as well as input, *recruits subsystems for participation in the supernet.*

Subsystems participating in the supernet are all exposed to the same tuning signals. Nonparticipating, well-adapted subsystems require no further tuning to respond optimally to their input. Well-attuned subsystems do not need the supersystem but continue independently on their own in parallel with other nonparticipating subsystems—until a certain mismatch occurs or attention is directed toward them, and reparticipation takes place.

The role of neurochemicals in neural net functioning can be easily appreciated with the above picture. The various network constraints are adjusted neurochemically: *the chemistry tunes.* Synaptic efficacy, for example, is under exquisitive and highly complex control by neurochemical modulation of the rate of neurotransmitter synthesis, release, transport and reuptake; this modulation process, in effect, tunes the connection weights. (The more transmitter available in the synaptic space, the more efficacious the connection.) Opiode peptides narrow the shape of the action potential, which limits the spread of an impulse in the axonal arborization.[20] So the functionally effective connectivity of the network is chemically modulated. Thus the many neurochemicals affect a variety of constraints on the self-organizing dynamical process and, accordingly, affect the network's evolution. *The brain self-tunes its neural nets by neurochemical means.*

Input from the environment and the body also constrain the brain's self-organizing evolution, as we have seen. When an input is clamped on or is of high intensity, it is the dominating constraint; normally, however, the input is in continuous flux, so it is a participating constraint, i.e., an influence. Conversely, when input is redundant, of low intensity, ambiguous or impoverished, other constraints become dominant; cognitive or affective constraints may then prevail.

In tuning the transfer function, connection weights, connectivity, and network parameters, the hyperspace topology fluctuates; this effectively steers the autorhoetic evolution of the trajectory. The system is to a considerable extent self-steering; the brain as a nonlinear dynamical system is holistically self-tuning as it intersects with its input. Out of the whole of these interpenetrated tuned constraints and the intersecting input, the brain qua nonlinear dynamical system flows along its constraint-satisfying trajectory.

2. Psychiatry and the new dynamics

The brain has been modeled above as a nonlinear dynamical system, and a sense of the potential richness of such a system has been gained. The brain's self-tuning capability has been especially emphasized. This understanding is applied in Section 2, with the aim of contributing to the development of a "dynamical psychiatry" that is tantamount to a paradigm change in psychiatric thought.

It should be noted that "dynamical" psychiatry is to be distinguished from the traditional Freudian "dynamic" psychiatry, although there is a clear relationship. Psychodynamics is founded on nineteenth century thermodynamics, whereas dynamical psychiatry is founded on the new nonlinear dynamics of complex systems,[21] which has succeeded the classical picture. In a sense, Freud's 1895 *Project for a Scientific Psychology* is updated in terms of nonlinear dynamics, which entails a paradigm change.

Biological psychiatry

The fundamental tenet of contemporary biological psychiatry, put in simplest terms, is that in mental illness something goes wrong with brain chemistry. Pharmacotherapy is a rational approach in that drugs correct the abnormal neurochemistry. What this means in terms of "dynamical psychiatry" is that something has gone awry with neurochemical self-tuning, which affects the dynamical evolution of brain states in mental illness. Pharmacotherapy retunes the brain to normality. The essential idea, which bridges biological psychiatry and cognitive science, is that *psychotropic drugs correct the brain's attunement*. This highly economical idea is not the information processing one

in which drugs used in psychiatry fix faulty neural hardware or modify the program; the idea is to adjust the maltuning of mental illness so that the brain becomes normally attuned.[22*]

Out of the intersection of the self-tuned brain with input from its surround, a sequence of behaviors is generated. That is, the person's behavior results from the intersection of input with the brain's instinctual, affective and cognitive attunement. The constraints on the evolution of the dynamical brain are altered in mental illness so that the state space trajectories are associated with behaviors that are characteristic of the different diagnoses. Correct the brain's attunement by means of drugs that affect neurochemical tuning, and the trajectory is altered and associated behaviors are normalized.

For present purposes, the important point is that for biological psychiatry in the new model, *mental illness is a primary disorder of the brain's instinctual, affective and cognitive attunement*. The biological psychiatrist corrects the brain's self-tuning by correcting the neurochemistry. The biobehavioral psychiatrist additionally adjusts learned constraints on the dynamical system through behavioral therapy and works to change the input, thereby adjusting the input constraint and other-tuning. The interpersonal psychiatrist is especially interested in linguistic inputs from the social world, which powerfully constrain the evolution of the dynamical brain system. Thus eclectic psychiatric treatment is variously directed toward adjusting neurochemically the tuning of tunable constraints, toward the learned constraints, and toward the various input constraints, including social ones.

A particular model within this nonlinear framework involves the relationship between electrophysiologic variables, the brain's attunement and the clinical presentation. The model we propose is that the clinical symptoms are related to abnormal attunements, which have global effects on system dynamics. The dynamics of the system are observable in electrophysiologic variables, such as the EEG. Therefore the model predicts that different types of clinical conditions will show EEG differences when nonlinear analytic techniques are applied to these variables. Note that we do not predict a one-to-one correspondence between current standard diagnoses and EEG parameters such as correlation dimension. Our prediction is that a reclassification of diagnostic categories based on nonlinear analyses will lead to more specificity and consistency in diagnosis, and more predictable response to medication or other treatments. Specific applications of this model follow in the text.

State space and nosology

Distinct diagnostic entities correlate with special state space characteristics, so diagnoses can be represented in state space terms. For example, the hyperspace in Obsessive-Compulsive Disorder can be characterized as being dominated by

a powerful attractor: the obsession or compulsion. (An obsession is an irresistable thought that the patient cannot get out of his or her mind, e.g., the thought of killing a child. A compulsion is a repetitive, irresistable behavior, such as handwashing.) A wide range of initial states falls into the attractor, so that the person keeps obsessing over the same idea or repeating the same ritual. The obsessive personality style is characterized by rigidity—the trajectory always ends up in one or another of the same small set of attractors—and ambivalence over alternatives, which is represented by cycling between equally powerful attractors. The highly emotional and labile hysterical style is marked by a fluctuating topology. Network tuning for the more hysterical individual can be easily influenced by someone else (suggestibility). The hyperspace of phobics is dominated by repellors that turn the trajectory away from certain states in which the phobic object is met (so that heights are avoided, for example). For Multiple Personality Disorders, there are widespread and formidable partitions (separatrices) of hyperspace so that the trajectory tends to stay within one widespread region but at times passes across the separatrice, shifting abruptly to a new region in which the trajectory is then confined; each breaching of the partition is associated with the emergence of a different personality with its own memory, wishes and way of being in the world. Thus in dynamical psychiatry these "cognitive disorders" are associated with distinct hyperspace topologies.

For Personality Disorders, there are characteristic constraints on perception, thinking, action and self- and other-relationships across a wide range of social and personal contexts. Particular constraints are associated with characteristic state space topologies. The dependent personality, for example, is tuned to settle into states associated with dependency and submission. *Personality traits, in general, are persistent attunements that shape the state space so that certain states* (governing paranoid or schizoid or avoidant behaviors, as the case may be) *attract the flow of the nonlinear system's evolution.*[23*]

With respect to Major Affective Disorder, a simplified example can be given that is useful for purposes of illustration. (See Figure 5.1.) Consider a three-dimensional state space where the X-axis is motor activity, the Y-axis is affect, and the Z-axis is the energy value. The system spontaneously evolves so that a state that optimizes constraint satisfaction is reached. The state of this system can be described by three numbers, describing the level of motor activity, the level of affect, and the likelihood of that level of affect and motor activity occurring. Thus a 3-D relief map is formed that indicates which level of affect and motor activity is most probable.

A patient with Major Depression having severe vegetative signs would have a basin in the region of low motor activity and negative affect. A person with Bipolar Disorder (manic-depressive)—see Figure 5.1—would have two basins, one in the region of low motor activity and negative affect and the other

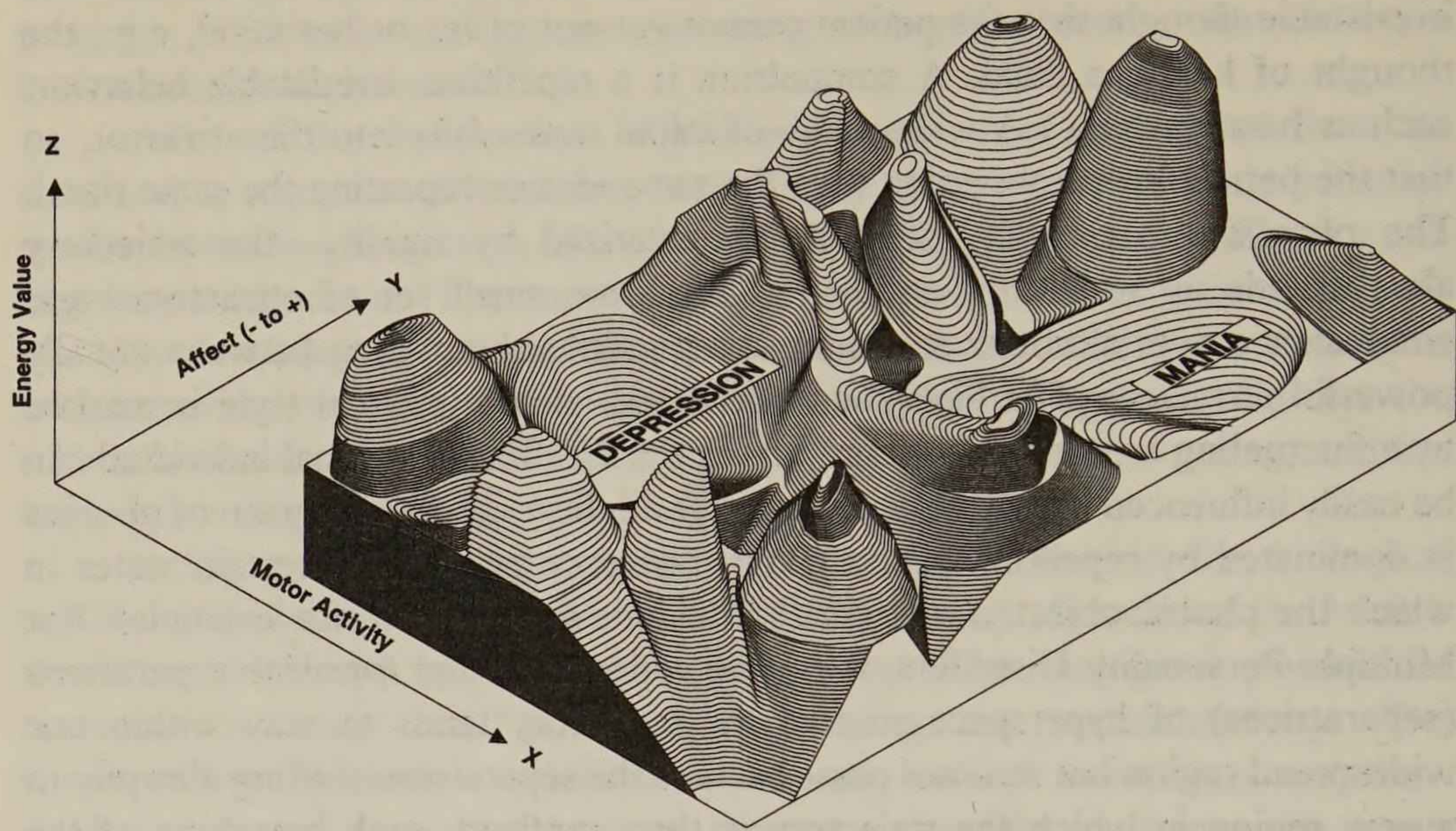

Figure 5.1: State space representation of bipolar disorder. The figure illustrates depressive and manic regions of the state space. The axes of the plane represent activity and affect, whereas the third dimensions, with its repellors and attractors (Rs and As), gives the sysem energy. Depression is in the low activity, negative affect region and mania in the high activity, high affect region. These regions are separated by a saddle barrier that is higher than the local repellors on either side. In an N-dimensional space, the number of ways of crossing the barrier decreases exponentially with the height of the barrier.

in the region of high motor activity and positive affect. The height of the ridge between these two basins would reflect the ease of transition between the two extremes. A low pass (low energy barrier) would indicate an easy transition between extremes and correspond to a rapid-cycling condition. A high pass (high energy barrier) would indicate a more difficult transition between the two states and correspond to a longer interval between cycles. This barrier between manic and depressive attractors is not impenetrable; there are passages through the N-dimensional barrier (which decrease in number exponentially with the height of the barrier). Nor is the barrier static; physiological factors may temporarily lower the barrier so that a shift between attractors occurs. The tendency of patients with Bipolar Disorder to evolve to a more rapid cycling pattern over time can be seen as a gradual lowering of the pass between the two

basins as the disease progresses.[24*] Thus the nonlinear dynamical perspective can be used to gain an intuitive picture of a mental illness.

Schizophrenia

Perhaps the acid test of the dynamical model would be a theory of schizophrenia. How can the various clinical phenomena pathognomonic for schizophrenia be explained dynamically? Does this provide fresh insights into the puzzling symptoms of schizophrenia?

Splitting

One of the several senses of "split" in Bleuler's original concept of schizophrenia (split-mind) is the splitting between affect, thought and behavior. Ordinarily we feel, think and behave in a coherent fashion; however, in schizophrenia affect, thought content, and behavior can be inappropriate to one another. (For example, the patient smiles in a silly way while talking of killing his father.) Over time there is incoherence, too, which reflects the tendency of the schizophrenic trajectory to bifurcate suddenly, say, from cooperation to complaints of being persecuted, i.e., to the experience of a paranoid world. There is a splitting up of the usual coherent attunement, in which systems participating in the supersystem are all tuned the same way. Incoherent tunings coexist in schizophrenia; *it is tuning that splits*. This concept of the splitting of tuning provides a basis for a new theory of schizophrenia.

Presumably this splitting of tuning is neurochemically mediated. That is, the normally coherent tuning splits up because of some abnormality in the neurochemistry of certain brain regions.[25] As a consequence, the tuning of affective, cognitive and behavioral systems splits. Correct the chemistry and the tuning again coheres. Thus in schizophrenia, according to the model, there is a pathology of brain neurochemicals (possibly monoamines) that results in incoherent tuning, which leads to the clinical phenomenon of splitting.

Autism

Schizophrenic patients tend to be caught up in an "autistic" inner world of fantasy that is wish-fulfilling and reality denying. As in dreams, the constraint derived from input loses power relative to constraints derived from wish and feeling. The normal balance between other-tuning and self-tuning is lost to the detriment of the former. Thus self-tuning predominates in autism, so that schizophrenic networks move toward attractors that are relatively free of reality constraints. (The self-tuning of autism should not be confused with the *cessation* of tuning in meditation.) The balance between other- and self-tuning

is neurochemically modulated, and it is disrupted in schizophrenia with its neurochemical pathology.

Delusion

Delusions are fixed beliefs unresponsive to "reality" that result from a powerful tuning. For example, a schizophrenic patient insists that members of the Mafia are watching him because the cars driving by his house look like Mafia cars. This "Mafia look" is experienced incorrigibly by the patient.

Paranoid delusion results from a tuning that shapes the state space topology so that the dynamical system tends toward certain subspaces where the attractors are associated with paranoid perceptions, beliefs and behaviors. *To be paranoid is to be tuned a certain way.* The paranoid schizophrenic may express the same delusional beliefs repeatedly, as long as the paranoid attunement lasts. And whatever the "reality," it must intersect with a paranoidly attuned brain that will settle into attractors that go with paranoid behaviors. Any perceptual or linguistic input constraining the dynamical evolution is given a paranoid twist. (This is the reason that one never wins an argument with a paranoid person.) Paranoid beliefs are the consequence of a paranoid attunement; the belief system is paranoidly tuned. Certain attractors that the belief system typically settles into, given the paranoid attunement, are brain states in which the patient believes he is being poisoned or believes that someone is against him.

Hallucination

Consider the schizophrenic patient hallucinating in a quiet corner of the ward. Hallucinations in schizophrenia are typically auditory but may involve other sensory modalities. Visual, somatic, olfactory, auditory, and other systems abnormally participate in the supernet at such times. For example, no one is speaking but the speech perception system participates nonetheless. Given its (paranoid) tuning, it follows a trajectory in which meaningful (persecutory) speech is heard. The tuning of the speech perception system may be split from the tuning of other systems; it is tuned to hear grandiose praise, perhaps, while other systems may have different attunements. More typically, all the systems are paranoidly and/or grandiosely tuned, including the speech perception system. The patient is paranoid about everything, and accordingly, the speech perception system is paranoidly constrained, so that what is spontaneously heard along that system's trajectory is against the patient.

This pathological participation may be understood as a reflection of a general tendency for disinhibition in schizophrenia. The participation of systems is normally inhibited, except in the case of a small mismatch between input and attunement or when the systems are attended to (as already discussed). Given a

neurochemically caused pathological disinhibition, over-participation occurs, and the trajectory of the abnormally participating system is determined by the tuning at the time, whether split or global. Listening for voices, as schizophrenic patients do, primes the hallucinatory process because attention causes participation and a concomitant exposure to tuning. In listening for voices, the speech perception system participates and is paranoidly or grandiosely or otherwise tuned, as the case may be.

Negative symptoms

The so-called negative symptoms of schizophrenia[26] include alogia, affective blunting, avolition, apathy, anhedonia, asociality and inattentiveness: the deteriorated patient does not care. These negative symptoms are thought to be related to a neurochemically determined hypofrontality (possibly hypodopaminergic).[27] In terms of dynamical psychiatry, negative symptoms reflect a decreased, *impoverished tuning* of system constraints so that hyperspace topology becomes static and less differentiated. Since the autorhoetic property of self-organizing, dynamical systems depends on a robustly fluctuating topology, the decreased tuning in schizophrenia leads to weak autorhoetic behaviors. Accordingly, in the relatively featureless topology, nothing attracts strongly, and the negative symptoms of schizophrenia result.

Comparison with Hoffman's proposal

Hoffman and coworkers have provided an explanation of schizophrenic phenomena in neural net terms.[28] They propose that the pruning of cortical synapses, which takes place normally in development and extends well into adolescence, is excessive in schizophrenia. There are a variety of aetiologies for over-pruning with the common result that network output becomes bizarre, due to the emergence of powerful "parasitic" attractor states which spontaneously arise. Parasitic states are induced "when multiple energy minima [attractors] coalesce to form a single, deep energy hole that pulls even distant inputs to itself."[29] These parasitic attractors do not reflect any memory previously stored in the over-pruned network.

Parasitic foci in cortical areas associated with cognition "elicit their pathological effects by altering speech perception or speech production processes by either influence or, episodically, complete control."[30] For example, in the case of hallucination, "if...a parasitic focus emerges in neural circuitry responsible for speech perception, fictitous speech percepts or "voices" could result."[31] When a parasitic focus dominates the memory system responsible for remembering and recalling stories, i.e., dominates narrative memory, paranoid delusions with fixed ideas can occur.

Whereas Hoffman locates the pathology in schizophrenia at the attractor, the present proposal locates the pathology upstream, in relation to the processes of tuning and participation, which have profound effects permeating all aspects of the person. It is the process of tuning that influences perception, shapes speech and alters narrative memory. A fixed attunement may alter state space topology so that a parasitic attractor is, in fact, formed, yielding the sterotypes that Hoffman's explanation emphasizes; however, a deeper and more comprehensive causal understanding of schizophrenic phenomena is gained in terms of tuning rather than in terms of parasitic attractors, which are the consequences of tuning pathology.

Discussion

The interpretation of schizophrenia within a nonlinear framework is that schizophrenia is a disorder of a self-tuning, recursively organized, nonlinear dynamical brain. The heterogeneity of schizophrenia, which takes many forms and has varying aetiologies, reflects the varieties of possible pathology—such as decreased tuning, incoherent tuning, and disinhibition of system participation in the supernet—with their underlying chemistries. Application of this interpretation predicts a dynamical system that is less organized, less coherent, and less stable in the schizophrenic condition than in the normal condition. Since the dimensional complexity of the EEG can be thought of as a general measure of the complexity of the underlying brain processes,[32] the model predicts that the dimension of the resting scalp EEG will be higher in schizophrenic subjects than in normals, due to the less organized, less coherent and less stable dynamics.

In addition, since neuroleptic medications ameliorate some of the symptoms of schizophrenia, the model predicts that the dimension of the EEG will decrease with a favorable clinical response to neuroleptics. Furthermore, the prediction is that the decrease in EEG dimension in response to neuroleptics will precede the behavioral response. This prediction follows from the model in that the behavioral response of the organism is constrained by changes in the structure and neurochemistry of the brain (changes in receptor density and synaptic connections, to name a few), which take time to develop. These structural and chemical changes depend on sustained changes in the moment-to-moment tuning. Since changes in the moment-to-moment tuning will be quickly reflected in the dimension of the EEG, these dimensional changes will precede the changes in behavior.

Two recent reports partially confirm the first hypothesis above. The first report[33] demonstrated that acute schizophrenics had a higher EEG dimension in the parieto-temporal EEG when compared with normal subjects and that schizophrenics in remission had intermediate dimensional values. They reported

no difference in the parieto-occipital EEG. The second report[34] partially supports the first hypothesis above. This study found that the dimensional complexity of the frontal EEG was, in fact, greater in the schizophrenic subjects than in the normal controls: however, the dimensional complexity of the central EEG was lower in the schizophrenic patients. Since this study used medicated patients, the decrease in central EEG dimension may have been caused by the medication, a reciprocality with the frontal EEG, or other factors. These possibilities call for a study of the EEG dimension in unmedicated schizophrenics and repeated after the subjects receive medication. In any case, it is apparent that the application of non-linear dynamics to psychiatry will not be simple and straight-forward.

Research support for the dynamical model

The dynamical model developed above is not currently implementable at the bench by computer modeling. There have been recent attempts to factor in some neurochemistry,[35] but the flowing, self-tuning capability of the dynamical model described above is presently beyond silicon implementation.

Empirical evidence, however, does bear upon the model. If the brain were a multidimensional, nonlinear dynamical system, then it would be prone to enter chaotic regimens. There is, in fact, increasing evidence that the EEG has non-integer, i.e., fractal, dimensions. Thus the system reflected in the EEG is chaotic.[36] The activity of single neurons has also been shown to be chaotic[37] (which is inconsistent with the widely accepted Hodgkin-Huxley equation for the transfer function[38]). So there is a growing body of evidence suggesting that the brain is in some sense chaotic.

Such research findings that the brain is chaotic support modeling the brain as a nonlinear dynamical system. Surely the computer is the wrong model if the brain is chaotic. The uncertainty of chaos is rigorously excluded from computer computation. Computers are designed to prevent the sensitive dependence on initial conditions of chaotic systems so that the results will be reliably predictable. This point has been obscured because both computers and dynamical systems are said to deal with "information," but here is the significant difference between the two: The "information" of computers has to do with data structures as strings of exact symbols, i.e., *representations*, that can be logically processed; in contrast, the "information" of dynamical systems is very different, of the Shannon-Weaver type that has to do with changes in *knowledge* about the system, i.e., with change in our uncertainty about the system state.[39] Brain chaos, then, turns us away from computer computation toward systems naturally described by nonlinear dynamics.

Research implications

Although bench researchers tend to look askance at modeling, a good model not only fits available data but suggests new hypotheses and topics for research investigation.[40*] Basar[41], for example, forsees "the renaissance of EEG" through the application of nonlinear dynamical methods.[42] These methods have been applied to the EEG of schizophrenic patients and have found dynamical differences from normals.[43] The fractal dimension of the EEG appears to increase in the transition from epileptic attack, to coma, to NREM sleep, to waking no task, to waking task and REM sleep conditions.[44] West[45] concludes, "The trend in these data seems to indicate that the dimension of the EEG time series is closely tied to the cognitive activity of the brain." Thus the nonlinear dynamical model opens up new areas of EEG investigation in clinical populations and the study of cognition.

Certain psychiatric disorders are strikingly dynamical in their expression. Bipolar Disorder cycles through polar affective states of mania and depression over the course of years. In so-called "rapid cyclers," a full cycle may take only a few days. Typically the "attacks" of mania and depression in the natural evolution of the disease are highly irregular. The dynamical model sensitizes us to wonder if there is an underlying deterministic structure in the noisy, natural trajectory of Bipolar Disorder. Do other episodic psychiatric disorders (e.g. Multiple Personality Disorder and Panic Disorder) that appear to be random have a course that lies on chaotic attractors?

Indeed, psychiatry is replete with time series data (behavioral, physiological, cognitive, clinical, social, etc.) that are distressingly noisy, but may, in fact, evidence deterministic chaos. Along these lines, Redington and Reidbord have provided nonlinear dynamical analyses of the heart rates of patient and therapist in psychotherapy, and they claim that characteristic state space patterns "are associated with clinically interesting psychological and behavioral events." They look forward ultimately to providing "equations of motion" for the dynamical interactions of the brain, the body and the mental processes. It is to these equations of motion that research suggested by the dynamical model is directed. Although a new and methodologically difficult field, nonlinear dynamics may prove to be highly productive for psychiatric research.

CHAPTER SIX

THE ERUPTION OF OTHER AND SELF

> If we had a keen vision of all that is ordinary in human life, it would be like hearing the grass grow or the squirrel's heart beat, and we should die of that roar which is the other side of silence.
> George Eliot

By way of introduction, let's consider a version of this text's trajectory through discourse space, that is, a strand in the subsheaf of *différance* that moves through my text. An incision point is made at the boundary between humanism (humanistic psychology) and cognitive science (connectionism). This boundary attracts deconstructive attention because of the war going on there. The concept of polarity is also released in the first chapter. The text then begins to work the disputed boundary, but now in opposition to the cognitive science side. A deconstruction of the metaphysical belief that the brain processes information begins (against Searle and the Churchlands), and an alternative connectionist view emerges in which self-tuning plays a prominent role. Chapter three shows that the concepts of self-tuning neural networks resonate with certain concepts of Heidegger and Derrida, when they are appropriated in a certain way. By the end of chapter three, a far wider boundary is released than the original one between humanism and connectionism, for a boundary has been cleared between postmodernism in the guise of Heidegger and Derrida and self-organizing, self-tuning neural networks.

Chapter four returns to the critique of brain information processing, this time directed against cognitive neuroscience. The alternative proposed reframes connectionism into nonlinear dynamical terms. In a nutshell: The brain is an autopoietic, autodynamic, self-organizing, self-tuning, nonlinear dynamical, complex system. Thus chapter four turns back from the broadened boundary and develops further the cognitive science side, without regard for postmodernism. Chapter five continues this strategy, applying the nonlinear dynamical frame to biological psychiatry.

This brings us to the present segment of the text. In Part I, another deconstruction takes place, this time directed against metaphysics leading the very good life within psychoanalysis. The deconstruction proceeds by my taking an informal text, a handout on psychotherapy found along my way, and, like an assiduous psychoanalyst, I focus on textual errors and other marginal events. Doing so—turning the very psychoanalytic technique against psychoanalysis—I find clear evidence of conceptual repression, flagged by its breakdown in the spontaneous eruption that ruptures through weak points in the found text. Whereas modernism is mechanical—pushed and controlled, like the car that is propelled by the combustion of gasoline while the driver-subject steers it—postmodernism is spontaneous and eruptive. Part II continues with the theme of the eruptive other, but here the emphasis is on its dynamical polarity with the self, the "polaron" of self/other. The polaron, we shall see, is not primary but "thrown" in the dynamics.

I. A DECONSTRUCTION OF CLASSICAL DYNAMIC PSYCHOTHERAPY

Deconstruction uses irreverent methods of approaching texts and discourse in general that have aroused strong feelings both in the academic world and the popular press. Deconstruction as a movement is decidedly internationalized as it traces its diffuse path through discourse space. Deconstruction will be applied here to classical dynamic psychotherapy, which brings together deconstructive and psychotherapeutic discourse. The aim is both to expose some traditional "metaphysical" assumptions of dynamic psychotherapy and to disclose a hidden alternative.

Here the method of deconstruction is first applied to a particular text on the technique of psychotherapy that happened my way, which I pounced on like a *bricoleur* (who uses whatever materials lie at hand to get the job done). This text becomes an "incision point" that prepares for later dissections. We come to see how metaphysics in many ways pervades the classical technique of dynamic psychotherapy.

Keeping an eye open for certain symptoms in texts, the deconstructionist behaves much as the practicing psychotherapist does with the various expressions of the patient. Derrida (1978) has studied Freud and is strongly influenced by him in this regard. The textual symptoms then become material for the deconstruction, for thematizing the hidden metaphysical expression in discourse.

Analogous to the psychoanalytic focus on the "psychopathology of everyday life," deconstruction is not applied to what is central to the text, where metaphysics holds sway, but to "marginalia" (Derrida, 1982a),

insignificant events seemingly extraneous to what the text officially says. Deconstructionists love textual errors, much like Freud's "slips of the tongue." Such marginalia are by convention disregarded as meaningless, but it is precisely here that the deconstructionist enters discourse. Textual slips in an informal text open the way.

1. Deconstruction of a psychotherapy text

The marginalia to be used for the present deconstruction of dynamic psychotherapy is not a book nor a journal article but a handout I happened on in the mess on my desk, dumped there who knows when. The handout, entitled "Introduction To Psychotherapy," was used in a second year psychiatric resident seminar. In the "lightness of Being," as Kundera says (*pace* Heidegger), this text came my way, a "found" text that provides an incision point for deconstructing classical psychotherapy. The text was written by a firmly classical psychoanalyst. It consists of the open question, "As a therapist do you" and then lists 60 questions about psychotherapy. (This text is reproduced at the end of the chapter.)

Of the 60 questions, 58 are of the type, do you do some specific act or other. For example,

> (23) Do you talk with your colleagues about patients you are treating?

These 58 questions are all issues of technique as defined within the classical framework. The exceptional two are "does the" rather than "do you" questions. The exceptional questions are the ones on which I want to focus.

One of the exceptions, question 37, is only apparent because the form of the question is determined by the preceding question.

> (36) Do you call your patient by his/her first name?
> (37) Does you [sic] patient call you by your first name?

Question (36) calls for its reciprocal, which determines the "does you [sic] patient" form. The mistake suggests that something hidden is at work here, which leaves a trace in the text at the shift from what the therapist does to what the patient does. The textual slip marks the reversal of the usual controlling/controlled dyad of therapist/patient.

Friends of psychoanalysis might object immediately that the therapist is the least controlling of people. Isn't the patient at liberty in the free-association technique to say whatever he or she wishes? Yes, but the therapist controls the

therapy through his or her technique. The found text is meant to teach young psychiatrists their trade.

As a therapist do you:

(05) Bill patient for missed sessions?
(12) Extend sessions beyond the usual limit if important material, issues emerge?

These are all questions that the therapist is supposed to decide, so obviously the therapist is supposed to be in control (if only the unruly patient will cooperate, instead of bitching about being billed for missed sessions and taking five minutes to write out the check while discussing trivial issues).

The major exception to the "do you" questions is this:

(25) Does this patient open the hour spontaneously?

Here the question is about what the patient does of his or her own spontaneous accord, not what the therapist does. The idea of the *spontaneity of the other* suddenly and briefly intrudes into the text. The proper form of the question for this text is this:

(25') Do you let the patient open the hour spontaneously?

Of course, the right rule for arranging the start of the hour is easily given for this question of technique, "Yes." But the present point is the shift from self—what I do—to the doings of others; that is what catches the deconstructive eye, the place in the text where the spontaneity of the other momentarily springs forth from its suppression in discourse and forces a shift in the question. I shall call this "spontaneous other" *autre*. Another interesting feature of question (25) is that it refers to *this* patient. None of the other 59 questions do. There are references to "the patient," "patient," "patient's," "your patient," "a patient," but *this* patient only appears in question (25). Now the question has become more sharply focused: on this patient. "The patient," "patient," "patient's" and "a patient" are quite indefinite; here the patient is effaced. "Your patient" is definite, in possessive form; here the patient is owned. *This* patient, however, is both definite and possesses itself, and is thus more fully *autre*. So at question (25), the list of questions temporarily changes form and the spontaneous self-generating *autre* becomes inscribed in the text, to be caught by the deconstructive eye.

The issue of question (25) is noteworthy: *Who speaks first?* Of course, to decide not to speak first is a form of control, given the dyadic structure of

psychotherapy. It is in the context of the initial moment of encounter, before dominance is established, at the brief interval of doubt where *autre* might also control by refusing to speak first, that the breakthrough occurs. (Oh, how the stubbornly silent adolescent patient throws a monkey wrench into psychotherapy!) Here the uncontrolled spontaneity of *autre* inscribed in a found text at question (25) breaches the *Gestell* (the metaphysical framework that historically permeates texts). Here a symptom of repressed discourse breaks through in a text. Since the psychotherapy "hour" invoked by the 60 questions is actually a "fifty minute hour," question (25) comes at the midpoint, the metaphysical *Caesura* between earlier and later in the course of the "hour." This shift provides a weak point where the repressed spontaneity of "the other" might break through. (My emphasis on the significance of question (25) may seem overdone but it is just such subtleties that psychoanalysts love.)

Let's continue with the significance of the location of questions in the series. The first six questions of the text have to do with what is generally called "the contract." Therapy is launched with a contract, a set of agreed upon rules which sets the conditions of the psychotherapy.

As a therapist do you:
(1) Participate in the setting of the fee?
(2) Monitor the monthly payment of the fee?
(3) Have the patient pay the fee directly to you?
(4) Hand the patient his/her bill?
(5) Bill patient for missed sessions?
(6) Discontinue treatment for non-payment of fee?

The "contract," which is part of the technique of psychotherapy, provides certain explicit axioms for the psychotherapy, rules agreed on at the beginning. The "contract" agreed to at the beginning is metaphysical *arche*, the origin at t=0, where time begins.

The final two sharply clipped questions of technique are also nicely representative of metaphysics:

(59) Start sessions on time?
(60) Finish sessions on time?

Time is thus serially segmented with a sharp beginning (*arche*) and end (*telos*), which is a highly metaphysical conception of time, very different from the incessant flow of Derrida's *différance* (1982b).

The lead-in question to this terse *denouement* refers, remarkably, to the detection of secret opposition, the exposure by "the other" of what has been hidden to the self.

(58) Explain a countertransference manifestation when it has been detected by the patient?

So just before the end, up comes the issue of what is both hidden and erupted, hidden to the therapist but detectable by the patient (whose name is quickly erased from questions (59) and (60) where time is closed off). Unconscious to the therapist and, accordingly, outside of his or her control, the spontaneous expression of the therapist in the countertransference erupts—the *autre*[1*] within—only to be quickly covered by the sharp denouement. In question (25) it is the spontaneity of the other that comes to expression; in question (58) the hidden spontaneity of the self—the other within the self—bursts forth. The eruptive autonomy of *autre* on both sides of the therapy dyad is a far cry from the ideal of either the patient or the therapist in classical dynamic psychotherapy.

2. Dissection: *Techne*

The idea that psychotherapy is a "technique"—a number of "you-dos"—is common to almost all forms of psychotherapy. The kind of psychotherapeutic technique, of course, varies widely—psychodynamic, cognitive, behavioral, gestalt, etc.—but there remains something common, in that a "technique" is applied. So "technique" as such tends to remain tacit in any discussion of psychotherapy. Technique is the way the therapist *tries to control* the psychotherapy so as to produce clinical improvement. (Of course, psychotherapists readily admit that their techniques are often inadequate for the task.)

Techniques are methods of proceeding in certain circumstances.

(20) Would you seek your patient's permission to present a paper including details of his case?

Of course, the best way of proceeding is not necessarily transparent, and further background may be needed. But the therapist does something or other in this situation of wanting to present a paper with details of a patient's case—telling or not telling, or abandoning the idea of presentation altogether, as the case may be.

To see what is entailed in conceiving of psychotherapy as a "technique" and to *deconstruct* "technique" by disclosing its hidden metaphysics, let's consider the metaphysical *techne* of the Socratic philosophers that persists today, hidden within psychotherapeutic technique. I shall use here Peters'

"Greek Philosophical Terms: A Historical Lexicon," which is the source of the following quotations.

Plato used *techne* mainly "in a nontechnical and popular way."

> The contemporary usage of *techne* was to describe any skill in doing, and, more specifically, a kind of professional competence as opposed to instinctive ability (P*hysis*) or mere chance (*tyche*). (p.190)

In Aristotle *techne* becomes

> a characteristic (*hexis*) geared toward production (P*oietike*) rather than action (P*raktike*). (p.191)

So in *techne*, something is produced. *Techne* entails a knowledge of how to do something—a know-how—but not necessarily a knowledge of why doing that something produces that product. *Techne* operates rationally, with *logos*, and its goal is *genesis*, which distinguishes it from purely theoretical knowledge (*theoria*) that has to do with being (*on*) and not becoming. (p.191)

Thus *techne* brings about the rational development of a product by control of the process.

> Importantly, *techne* must be distinguished from *physis* (nature). *Techne* is an external not an internal principle of *genesis*, which sets it off from *physis*... (p.191)

There is something to be changed and something external that brings about the change. *Physis*, in contrast, is for Aristotle the agent of change *for the things in which it is immediately present*; *physis* is immanent, an internal principle.

> ["e]nsouled," i.e., living, things, have within them both the principle of movement and the initiator of movement, and they thus differ from inanimate things that have within them the passive (P*aschein*) principle of movement but not the active (P*oiein*), which consequently must operate from outside. (p.159)

In *physis* the *genesis* is internally spontaneous, whereas in *techne* the change is externally driven, the product produced by a producer. *Techne* both initiates and determines the process of producing and thus dominates *genesis*. *Techne* is the form of external pragmatic control that prevails in all but two of the 60 questions, *viz.*, the two where *autre* breaks through. In *techne* the principle is applied to the other as object, whereas in the case of *physis*, the principle is always already of the other.

The technician for Plato is a craftsman (*demiurgous*). For example, the potter takes the amorphous matter (*hyle*) and through the techniques of pottery produces a pot in accordance with his a priori knowledge of forms (the so-called "Platonic idea"). Analogously, the Universal Spirit or Demiurge produces the cosmos out of chaos. The psychotherapist is supposed to produce clinical improvement by using proper technique on the clinical "material."

The other, then, is dominated, at least potentially, by the therapist whose use of technique inherits the metaphysical meanings of *techne*. The spontaneous upsurge of *autre* at two places in the text is inconsistent with the *techne* of psychotherapeutic "technique." Indeed, *autre* as spontaneous internal principle of the other is in the realm of *physis*. The therapist's *techne* encounters the patient's *physis*. In the found text, for which the therapy is completely controlled by the therapist, *techne* is overwhelming, but there are traces of *physis*, for both patient and therapist, erupting at places in the text where control softens, that is, at the *caesura* of question (25) and immediately preceding the final pair of questions.

In the clinical situation, however, what the psychotherapist does *constrains* rather than controls the patient, *constrains* the spontaneous upsurge of the "mentally disordered patient" as DSM IV-codable other[2*], the clinical *autre*. There are many other constraints operative on the spontaneous *ekstasis*[3*] of *autre*, so psychotherapy must vie for influence on the outcome.

3. Further dissection: Psycho*dynamics*

We saw in the incision that *autre* is spontaneously expressed in the text in two places: at the midpoint where the text refers to the therapist's extrinsic other (i.e., the patient) originating action, and just before the end, when the therapist's intrinsic other—the unconscious—breaks through ekstatically and is detectable. For the rest of the text, "Introduction to Psychotherapy," the therapist-self dominates the patient-other (making contracts, controlling time, and various other doings) through the application of the techniques (*techne*) of psychotherapy.

The self/*autre* relation is "vs." and designated here 'self↔*autre*'. In the text the relation is normally completely dominated by self in a "winner-take-all" fashion, so we do not notice the opposition; however, there are rupture points—halfway, just before the end—where the suppressed *autre* erupts to expression. Using the key term of classical psychotherapy, the self↔*autre* is "dynamic." There is conflict, opposition, and also compromise. (But continuing the deconstructive approach, we shall see that it is precisely Freud's dynamics that are erased from post-Freudian texts, while retaining the emptied name "dynamic.")

In this section, the "dynamics" of psychodynamics are further dissected. The particular text to be considered here is Erdelye's *Psychoanalysis: Freud's cognitive psychology*. In a section entitled "Psychodynamics" near the end of the book, Erdelye observes,

> *Psychodynamics* (or *dynamics*) is one of the most bandied-about terms in the psychoanalytic literature. Yet it is rarely defined. (p.212)

"Psychodynamics" is indeed so familiar a term that we assume it is well understood. Psychodynamics has an "association with notions such as drive, force, energy, conflict" (p. 212). So "psychodynamic" branches out conceptually to Freud's economic theory. Freud's dynamics, the text continues, are based on physical science. (Freud's economic theory has a principle of energy conservation based on the first law of thermodynamics and a tendency to change toward lower levels of energy [i.e. the pleasure principle] based on the second law.) The text then quotes Freud from the 1917 "General Introduction to Psychoanalysis" (1961). The aim of "our psychology," Freud says, is to conceive of mental phenomena as

> brought about by the play of forces in the mind, as expressions of tendencies striving toward a goal, which work together or against one another. We are endeavoring to attain a *dynamic conception* of mental phenomena. (p.213)

So the term dynamics refers to the play of cooperative and competitive forces. Erdelye is critical of the "force" metaphor and replaces it with the notion of "interaction."

> In sum, the most general meaning of *dynamics* in psychology, as in literature, is *interaction*...The crucial feature of any psychodynamic theory, Freudian or non-Freudian, is the description of some interactive phenomenon. (p.216)

And then, pulling far away from Freud, "interaction" gives way to *communication of information* along the following slippery slope (pp. 217-218).

Psychoanalysis, the text states, is "distinctive as a dynamic psychology" only in its emphasis on certain interactions having to do with motives and cognition. Indeed,

> the dynamic character of psychoanalysis and modern cognitive psychology are fully compatible, and ripe for integration. (p. 217)

Because the historical roots of cognitive psychology are in information theory, mathematical decision theory, and artificial intelligence,

> cognitive psychology has tended to be framed in terms of "ideal observers" and "information processing" (p. 217).

Psychoanalysis, on the other hand, because of its clinical roots, frames things in terms of "*non*ideal observers and tendentious information *mis*processing" (p. 217). This is merely a difference in "theoretical focus" (p. 217). So Erdelye is sanguine about replacing Freudian psychodynamics and the closely related economic theory with information processing ideas.

Erdelye is sensitive to the seeming incoherence of the idea that psychodynamics is a matter of information processing.

> The computer analog does not *naturally* yield interest in the strange problems (from its standpoint) of a special class of computing systems—humans—who are often motivated (by some wish or fear) *not* to compute, or not to compute correctly. (p. 217, italics original)

Nonetheless, the computer "is fully capable of describing and even simulating" (p. 217) human computation. With this conversion of Freudian dynamics to computer-like information processing, the "play of forces" is erased from the text.

For Freud, dynamics are reflected in the "ego" being caught in the unenviable position of mediating among various forms of *autre*: (1) external reality, (2) internal reality (unconscious wish) and (3) superego. The competitive and cooperative interactions between these three forms of *autre* loom large in the economy of Freudian psychodynamics but disappear with the computer metaphor of cognitive psychology. The conflicting upsurge of the *autres* in a play of forces mediated by the ego is submerged under the notion of "*mis*processing," except in the marginalia, where the repressed may come to dominate expression.

Erdelye is explicit about replacing the concept of "force" by the *sampling* and *weighting* of information (p. 100-103). Information does not literally cooperate and conflict; instead certain information is sampled and heavily weighted by some criterion or other, and that weighted information is what is used in processing. Nothing pushes against anything; there is no immediate conflict (*confligere*, to strike together).

It should not be thought that the erasure of dynamic conflict—things pushing against each other—is confined to Erdelye's text. As early as 1947, a polemic broke out against Freud's economic theory within psychoanalysis. Kubie found "all so-called economic formulations a species of *ad hoc*

speculative descriptive allegory, in pseudo-quantitative terms" (p.518) and Holt observed,

> So long as it tries to hold on to an anachronomism like psychic energy, however, psychoanalysis will have great difficulty in progressing beyond Freud's monumental contribution. (Holt, 1967, p.38)

There are longstanding critiques of the economic theory that find it scientifically and conceptually indefensible and, furthermore, not essential to psychoanalytic theory[4]). These critiques tend to erase the spontaneous play of forces from psychoanalytic texts. The result is that psychoanalysis returns more staunchly to metaphysics.

What is lost from Freudian dynamics in the erasure of the economic theory is the idea of polarities united in a relationship of opposition. (This idea reflects, perhaps, a certain Hegelian tendency of Freud's.) PostFreudian dynamics as metaphysically retrieved are without polarization and opposition, as can be seen from a discussion by Peterfreund, where conflict is thought of as *logical* incompatibility.

> Programs which contain instructions that are logically incompatible with the attainment of a desired goal are important examples of defective programming. Clinically, these programs result in conflict. (Peterfreund, 1971, p. 170)

Mere logical incompatibility is pale compared to the energetic push and shove of Freudian dynamics. The quest for dominance is covered over by "defective programming."

The criticism of Freud's original notion of dynamics is not, I think, without merit, but radically new conceptions of dynamics are now available.[5] Here the "conflict" is between incompatible constraints on a self-organizing, nonlinear dynamical process that tends to find a good consensus across constraints (a "compromise," as Freud (1900/1953) said). The "conflicting" constraints do not bump heads locally, in the cathexes and countercathexes of neural representations, as in Freud's *Project* (1895/1966), but *globally*, through participation in the dynamical whole, where the "conflicting" constraints interpenetrate. Thus in making use of recent models, *psychodynamics retains Freudian polarity but globalizes the conflict*.

The new dynamics is well launched in cognitive science, in the form of "connectionism" or "neural net theory." Here the brain, and by extension the human being, is a dynamical system that evolves under constraint, a self-organizing, multiply-constrained system that "settles" or "relaxes" into solutions for the problems posed by input. Due to nonlinearities, the dynamical system can abruptly, dramatically and unpredictably change states. The nonlinear

dynamical system is prone to chaotic regimes where *causal connection of present to future is lost* because of "sensitive dependence on initial conditions." *These systems are, in principle, unpredictable*. *Autre*, too, has something of this unpredictable quality in its upsurge, eruption, *ekstasis*. There is a possibility, then, that *autre* can be modelled as a nonlinear dynamical system.

4. Exposure: The patient as *autre*

The preceding attempt to deconstruct classical dynamic psychotherapy has focused on technique as "you dos" that control the therapy and has offered instead a view of the patient as *autre*, spontaneous other, erupting more or less fractiously or dispiritedly, as the case may be, along his/her world trajectory. The patient as *autre* is self-organizing and self-tuning. The therapist *participates* in the self-organizing process of the patient's evolution. The spontaneity of the patient erupted into clinical phenomena is constrained in psychotherapy and, hopefully, a more salutary eruption occurs.

When the therapist uses medication, this too comes under participation. The patient is no less spontaneous and eruptive than before, although with drug-induced "clouding of consciousness," as in sedation, the *ekstasis* is less rich. This is because certain key constraints on the self-organizing dynamical system's evolution are neurochemically tuned. So if the patient has some neurochemical dysfunction that malconstrains his or her spontaneous evolution, the drug can hopefully correct it—but this does not make the patient any less *ekstatic*.

In *psycho*therapy, the therapist participates at a different level. The context of participation is social rather than neurochemical. (Drugs, too, are given in a social context.) The context of feelings and motivations is also important in psychotherapy, for both patient and therapist. The context of language, too, is important for the dynamical process of psychotherapy. Thus social practices, drives, feelings, and talk also constrain the dynamical system. In general, then, psychotherapy "tunes" the constraints on a nonlinear dynamical process. What is expected (by *das Man*, "they"), how the situation feels, unacknowledged wishes, and what is said, all tune the constraints on the evolving dynamical system that is the patient as *autre*, who is fundamentally unlike the hyletic, predictable patient of metaphysical tradition. Indeed, it is the patient as spontaneous *autre* who is disclosed by the present deconstruction of classical dynamic psychotherapy.

II. DREAMING OF *AUTRE*

I dream that *I am playing American football as a linebacker. I am very active in the line, dominating play. I notice in the dream that my arms feel weak, as my opponent attempts to block me; nonetheless, I am forcing my opponent back.*

This dream came when I was in Iowa for my mother-in-law's funeral service. In driving from the airport two days earlier, I had noticed the exit to the University of Iowa, and I had a brief thought of "Big Ten" football. The evening of the dream I had been at the train station seeing some of the relatives off. At one point my twin daughters had boisterously wrestled with each other, while standing on the station platform, waiting for the train to come in. My dream lineplay was somehow like their struggle but expressed in football terms. My playing football in my dream "alluded," as Freud likes to say, to the struggling twins.

Death was, of course, very much on my mind at my mother-in-law's funeral. I was situated for Death. Since my own mother had died five months previously, those scenes of death were still fresh in my mind, resonating with the current situation. Not only was my horizon one of death, but violent death had actually come up obliquely at the train station. A little cousin was running around, a bit out of control. As the time for arrival of the Southwest Chief drew close, people, myself included, began to feel anxious about the little boy running near the track. What if he should fall under the train, by some chance quirk of fate, and violently die?

The violence of this thought resonated with the violence of the struggling twins. I had been momentarily startled when I first noticed the twins wrestling. It appeared unusually combative for those usually peaceful, identical girls. The twins looked out of control in their wrestling, out of control like the little boy, *out of control like uncontrollable death*. I was momentarily jolted by their well-matched struggle.

So death was definitely there on the platform—for me at any rate. I did not experience a big death *angst* while waiting for the train to come in at the small town Iowa train station, with the little cousin running around and the wrestling twins, but just the fringe of a shudder over *death*. It was an issue with which I had not adequately dealt, neither my own nor my mother's. Death was poised that night to constrain the evolution of my dream life. The other in my dream, the opponent whom I dominated, was death.

There was, of course, a lot more going on this dream. At that time, my generalized arthritis had been kicking up a bit, and I was worried. My arms felt weak when I carried my suitcase (a secondary effect of the arthritis). Both my

mother and my mother-in-law had been ill before they died, and I was feeling ill but officially optimistic. So the meaning of "illness" associated with "death" remained unfinished business and was operational in the formation of the dream. The memory of my arms feeling weak—a perceptual correlate of my illness—was recruited to the dream.

I can say more about "how I found myself" at that time, Heidegger's *Befindlichkeit*: a feeling with a situatedness, an affect and a readiness for a certain discourse. I flew to the funeral service from the American Psychiatric Association meetings, where I had been somewhat "off balance." I had felt isolated and unappreciated at APA, marching to a very different drummer than the other psychiatrists. I took these feelings to Iowa, where I experienced no validation and continued to feel isolated. Death is the ultimate estrangement.

Situated in the problematic of death, my dream offered a solution. The dream life in which I vigorously played football solved my unresolved, correlated issues having to do with death, illness and estrangement. I was not estranged in the dream world but fully engaged in a team sport. In my dream life, I was not worried about health and fearful of death. Instead my dream path of greatest harmony was to encounter my opponent, *autre*, boldly, confidently, and fully engaged. I was out of balance with the losses and the other issues in my life, and the dream portrayed a path which, if followed, would restore me to balance. This is Jung's theory of dreams as compensatory for waking imbalance.

So this was a dream of altereity (otherness), death as the archetype of the other. I wrestled with *autre* in my dream and succeeded—this time—in overcoming him. The dream solution to my existential problem of death pointed to spirited action that had dissipated greatly in my life under the impact of losses. Action is the antidote to depression.

There was another intriguing factor at work here. The evenly matched, struggling twins, who are the same yet other (reminiscent of Heidegger's [1969] "identity and difference"), are an archetypal expression of dynamical polarity. A symbol of polarity thus offered itself to the dream process, under the provocation of death, while I was "in" the *Welt* of writing this book. The struggling twins resonated with my writing project and so were party to the dream.

The dream, then, dealt with both emotional issues and intellectual issues in my life. At the time of this dream, I had not fully distanced myself from the concepts of information processing, representation and computation, nor had I fully appreciated the significance of polarity for my evolving thought. Recall the incision point of this text in chapter one, the polemic between the editor and me, in which *polemikos* writes polarity—releasing polarity as a theme. But this is an arbitrary "origin." No absolute beginning can be found, only the surfacing of polarity in this text—Heraclitean themes of dynamical polarity—that resonate with personal existential issues and are expressed in the dream.

*

In the deepening dusk the rattler sounded, the other side the woodshed, a mite up the hill. It is always a bone-chilling sound close at foot, but even 50 yards away it is formidable, like hot twisting steam vented from a hidden magma. (My daughter Rachel later says that it is the sound the school librarian makes when she wants you to stop whatever you are doing.) The rattling continues on ominously and I shudder.

Where are the cats? They must've got a snake! Tiger is in the house—keep him in!—but Prince John is nowhere to be seen. It is almost dark, and it must be Prince John facing the rattler, that small, thin, castaway from the mill store, that black cat who somehow—a child's premonition—earned the title "Prince." They say cats are too quick for rattlers, but we lost Strawberry Shortcake a few years back from a rattler bite right in the center of her forehead. Now Prince John plays with Death, just beyond the woodshed.

I grab a flashlight and shine it ineffectually past the shed up the skid road which is barely discernable in the dark. The twins climb on top of the old Volkswagen camper and shine their lights up the hill, flashing on abruptly shifting, fragmentary worlds as they swing their lights back and forth through the wind-rippled foliage. It's John! They have glimpsed him through the trees. "Come Kitty! Kitty! Kitty!" The twins begin to cry while screaming for Prince John.

It's no use. The rattling continues, slowly making its way up the hill—the impenetrable netherland—drawing John away, withdrawing into the heart of the darkness. We return to the house, the twins still sobbing, and leave Prince John to his fate.

I wait on the porch, following the trajectory of the life/death polarity in the night. My wife calls, "Come Kitty! Come Kitty!" He won't come. (Don't distract him: His attention momentarily caught by the lure of his mistress's voice, the fangs strike the forehead and pierce through the thin cat skull to the brain. John's mind is poisoned.) Don't call! He's lasted this long, and it ain't got him yet.

The rattling lasts an hour or so, out past the woodshed. After awhile Prince John shows up nonchalant and wants to get in. Once he's had his Friskies, he wants to go out again. Keep Kitty in, Ma, that rattler's still out there...

When I go to sleep that night, I have serious unfinished business. Sure Prince John deferred his nemesis, but the sound of the rattling going on and on has penetrated me, unnerved me. Death strikes at the place where Athena springs forth from the brow of Zeus, in the *Sprung* of thought. On this score I feel vulnerable. I always protect my head. I don't even like to dive. The intellectual's version of death fear. (Some other guy's worryin' 'bout his

pecker.) Getting into bed, I'm *rattled*, overwhelmed by my encounter with death.

That night I have a God awful nightmare. I have had this kind of gruesome nightmare before, and this one's a doozey. I don't even want to think about it several nights later at the writing.

Gruesome, diabolical, sinister... All the dream people look sinister, evil. There is murder going on. I'm in the middle of the situation, horrified, and I can't get away.

I awake feeling quite shaken and hug Maria's warm body, saying "I had a bad dream," which she drowsily acknowledges. It is difficult for me to get back to sleep.

*

In this dream *autre* again appears, this time in sinister form. This paranoid *autre* is complement to my waking self that was shaken by the snake's solicitations. The waking self, *threatened* by the rattling sound and identified with Prince John (masculine) and Strawberry Shortcake (feminine), encounters the issue of death through brain poisoning. The waking self is ill-prepared to deal with this, and so is rattled by the encounter with death, the other into whom all we Daseins must dissipate.

The *autre* that starts up in the dream complements the waking self that is carried forward into dreaming. In dreaming, the threatened ego finds itself in a threatening world (just as in the waking life of paranoia). Unlike the football dream which expressed the dominance of self in the polarity, this dream expresses the dominance of *autre*, in the form of the rattlesnake that for me symbolizes death.[6*]

What these two death dreams show ontologically is that the self is always already accompanied by an other, which includes the world and the people in it. I focus on the other as a person here. In dreaming the other must be created. The dreaming self is yoked to its other, for there is no self without other to mutually form the boundary. So the self rattled by death goes paranoid and a persecutor fills in. The dream persecutor complements the rattled dream self. In contrast, in struggling against death—over against the other in the football dream—self requires the vanquished for its own definition. Self/other is a unit, a "polaron," balanced or unbalanced, as the case may be.[7*]

The struggling twins symbolize the polarity between self and *autre* and also thematize polarization as such. (These twins often act like polarons: If one loves Chinese food, the other hates it, and in the balance, we eat at home.) Prince John symbolizes the active Oedipal self in polarity with the Oedipal

other, i.e. Father, authority, *logos*... (The Prince, after all, is the son of the King.) Strawberry Shortcake symbolizes the passive Oedipal self, brain-poisoned and, thereby, intellectually castrated, which is the feminine according to the male Oedipal stance. When the self becomes rattled (solicited by the sound) and overwhelmed, it requires the paranoid form of the Oedipal other to form its proper boundary.

Out of dynamical polarity, then, comes boundary, distinction. Distinction is thrown in the eruption of dynamical polarity. The self/other polaron in its myriad expressions is always derivative of the dynamical flow. My death dreams show the polar struggle: The self faced with death in waking fills out its own complement in dreaming, vanquished or persecuting, as the case may be.

Death is the subsidence of polarity. "Nothingness" is not the absence of presence (as in metaphysics) but the absence of polarity. When the dynamical process ceases, then all distinction fails. In death, not only distinctions maintained within the system fail but the very system/other distinction fails too. In death, the very boundary formed and maintained in *autopoiesis* fails.[8] In autopoietically sustained life, its boundary with the other continues while it evolves. Within this monadic boundary, self/other erupts in the dynamical evolution, whether dreaming or waking.

APPENDIX

INTRODUCTION TO PSYCHOTHERAPY

As a therapist do you:

1. Participate in the setting of the fee?
2. Monitor the monthly payment of the fee?
3. Have the patient pay the fee directly to you?
4. Hand the patient his/her bill?
5. Bill patient for missed sessions?
6. Discontinue treatment for non-payment of fee?
7. Maintain a set frequency of sessions?
8. Make up for sessions you must cancel?
9. Alter the frequency of sessions to meet patient's needs?
10. See patients more frequently than once a week?
11. See patients less frequently than once a week?
12. Extend sessions beyond the usual limit if important material, issues emerge?
13. Shorten session if the patient has nothing to talk about?
14. Do you chat informally with the patient before and/or after the session?
15. Interrupt session for phone calls?
16. Do you complete insurance forms for the patient?
    (If clinic policy gives you no option, answer as you would in seeing patients privately.)
17. Do you inform the patient about what you have included in an insurance report (e.g., diagnosis, etc.)?
18. Do you discuss the patient with a referring doctor?
19. Do you tell the patient you have a supervisor?
20. Would you seek your patient's permission to present a paper including details of his case?
21. Do you speak with family members and "significant others" (employees, teachers, etc.)?
22. Do you allow the patient to bring a spouse or a parent into session with him?
23. Do you talk with your colleagues about patients you are treating?
24. Do you talk with your friends or family about patients you are seeing?
25. Does this patient open the hour spontaneously?
26. Do you direct the patient to issues which you feel should be discussed (i.e., Do you have an agenda for the session)?
27. Do you change the subject when you feel the patient is "off the mark"?
28. Do you suggest a subject for patients who have difficulty starting?

29. Do you allow silences to continue for more than a minute or more?
30. Do you listen for certain topics or issues to come up?
31. Do you give the patient your home phone number?
32. Do you give patients medication?
33. Do you offer non-psychiatric medical advise?
34. Do you examine the patient physically?
35. Do you touch your patient?
36. Do you call your patient by his/her first name?
37. Does you patient call you by your first name?
38. If your patient were acting in a play would you go to see the play?
39. If you knew your patient would be attending a dinner party, would you attend?
40. If your patient were attending a scientific meeting, would you go?
41. If your patient were hospitalized for a medical or surgical problem, would you visit him/her?
42. Answer a patient's question about your professional training?
43. Answer a patient's question about your age or where you come from?
44. Answer a patient's question about your religion?
45. Answer a patient's question about your marital status?
46. Answer a patient's question about whether you have children?
47. Tell a patient when you are going on a vacation?
48. Comment (non-interpretive) on others in your patient's past (e.g. "Your father was a controlling man")?
49. Comment (non-interpretive) on others in your patient's present (e.g. "Your boss sounds rather unreasonable")?
50. Advise a patient to take certain courses of action?
51. Caution a patient against a proposed action?
52. Caution a patient against any major life decision until it is discussed in therapy?
53. Express approval of a patient's behavior?
54. Express disapproval of a patient's behavior?
55. Share some ethical position on a controversial issue?
56. Offer financial or legal advice to the patient?
57. Admit to the patient when you are angry or displeased with him/her?
58. Explain a countertransference manifestation when it has been detected by the patient?
59. Start sessions on time?
60. Finish session on time?

CHAPTER SEVEN

POSTMODERNISM AND THE DREAM

A dream one dreams alone
Is only a dream one dreams alone
But a dream more than one dream together
is REALITY.

From a song by Raul Seixas

Postmodernism and dreaming will be "thought together" here. I attempt to find a semantic resonance in which the two contexts, postmodernism and dreaming, might participate. My conclusion is that *the dream is deeply emblematic of the postmodern.* On the way to this conclusion, some important philosophical issues having to do with "truth" and "reality" will be opened up.

Before discussing postmodernism and its predecessor, modernity, I must say something about emblems. An emblem is something that suggests something else; we can easily see the something else in the emblem. The eagle on the battle flag tells of the army division's fierceness and strength in virtue of the eagle's exemplary fierceness and strength. It will be shown that the dream portrays postmodernism in exemplary fashion. Our dreams remind us of postmodernism, serving as emblems.

1. Modernity

"Modern" is a term to which we are well habituated. It sounds almost old fashioned. The term "postmodern" is increasingly seen, but is postmodern anything more than the name for the current phase of the modern? Or does postmodern signify a radical change from modernity?

Modernity is usually considered to have begun in the 17th century, spanning from the time of Galileo, Descartes, Bacon and Newton to the last few decades of this century when postmodernism has been self-consciously proclaimed. Modernity is classically rooted, however, in the Socratic philosophers of ancient Greece. Indeed, modernity is another name for the metaphysics deconstructed in previous chapters. Some important characteristics of modernity are as follows.

One characteristic of modernity is its reliance on *rationality*. Rationality here encompasses reason, by which I mean not practical reason but rule-governed, logical, linear thinking, as in mathematical computation. We find quintessential rationalism in current information processing approaches to the mind. Modernity is also characterized by its belief in the possibility of obtaining *decontextualized timeless truths*, that is, universal truths that stand alone, independent of context. Another important characteristic of modernity is its many *dualisms*, which bedevil the tradition back to Socrates (e.g. subject and object, beginning and end (*arche* and *telos*), grounded and ungrounded).

2. Postmodernism

Postmodernism entails a profound shift from modernism, indeed a paradigm change in contemporary thought. Postmodernism can be seen in philosophy and critical theory; the work of Martin Heidegger and Jacques Derrida are taken as representative here, although they by no means exhaust an unrepresentable movement. But postmodernism can be discerned in science, too, in the work of David Bohm, Fritjof Capra, Karl Pribram, Ilya Prigogine, Francisco Varela, Kunio Yasue, and other dynamical and holistic thinkers. Postmodernism is a very broad front that brings a revolutionary change in the way we think of the world, our brains, our selves, and our texts.

Any discussion of postmodernism is complicated at the very outset since postmodernism puts up a tremendous resistence to definitions, essences and other specifications that would nail down what postmodernism is.[1] Postmodernism has a fluid, uncontainable, changing quality. Nothing here is immutable. No truths are certain and eternal; truth is continually capsized in postmodernism.

Postmodernism even holds that the author does not have privilege with respect to what he or she has written (Derrida, 1978). Once the text enters discourse, it is there for anyone to *appropriate* for her or his own use in his or her own context. This goes against bourgeois property rights and, thereby, earns widespread disapproval of postmodernism.

Postmodernism is not only appropriative of modernistic texts but is characteristically *self-appropriating*. That is, in postmodern discourse, texts are continually made use of in new texts. This is the way that postmodernism advances: Not by the accumulation of knowledge and logical progression but in the manner of the *uroboros*, the snake that feeds on its own tail. Postmodernism continually cannibalizes its other and its self. Or, to use a different image, think of the baker folding the dough and pressing it back into itself; postmodernism turns texts back into itself. In this folding back process there is, paradoxically, both fragmentation and enrichment. Postmodernism appropriates its own

postmodern texts by continually recontextualizing them. *Postmodernism has an evolving, dynamical complexity that cannot be completed by obtaining ultimate truth.* Postmodernism just keeps going and going and going.

Given this fluid quality, postmodernism can't be defined at the outset. To borrow an image of Derrida's (1981), we can think of postmodernism as a "sheaf" of interlacing strands, like a hay sheaf standing in the field. The strands of the sheaf may break off and new strands enter in. Some postmodern strands will be picked up here, none of which give the essence of postmodernism, some of which are disputed even within postmodernism, and some of which are tantamount to appropriations of postmodernism that other postmodernists will resist. Postmodernism truly encourages a thousand flowers to bloom.

The image of the sheaf of interlacing strands is important. One objection to postmodernism is that it presents nothing new since one can easily find postmodern notions in modern texts. For example, the subject/object dualism that is savaged by postmodernists is also severely criticized by some modernistic writers.[2] But one straw doesn't make a sheaf. Furthermore, modernity's denial of subject/object dualism is computational and rational, unlike the antidualism of postmodernism or the nondualism of transpersonal psychology. Thus postmodernism comprises a fluid sheaf of strands, some of which are also claimed by modernity and some of which are differently construed by modernity. It is the entire sheaf that counts.

A presentation of postmodernism is incomplete without some mention of the strongly negative feelings postmodernism can arouse. This is, in no small measure, due to its provocative style.

> Post-modernists in all disciplines reject conventional, academic styles of discourse; they prefer audacious and provocative forms of delivery, vital and intriguing elements of genre or style and presentation...Such forms of presentation shock, startle, and unsettle the complacent...reader. They are explicitly designed to instigate the new and unaccustomed activity of a post-modern reading. Post-modern delivery is more literary in character while modern discourse aims to be exact, precise, pragmatic, and rigorous in style. (Rosenau, 1992, p. 7)

Although the present chapter is only mildly postmodern in style, its rhetoric is the kind of thing that staunchly modern science types hate. Indeed, the polemic—the war of words—is a typical postmodernistic stylistic ploy (which Derrida [1978] has used to his advantage). In contrast, the texts of modernity appear to be objective and dispassionate on the surface, and the writer fades from view. These technoscientific texts of modernity have hidden behind them, of course, great wells of passion and the spirit of domination. Technoscientific indignation about the postmodern style marks the place of paradigm clash.

3. The eruption

There is a spontaneity, an eruptive quality, an *Ursprung* (Heidegger's term), a kind of primitive springing forth, that is a characteristic strand of the indefinable sheaf that is postmodernism. A text spontaneously erupts in the movement of discourse. Our very existence is eruptive in that we always already find ourselves *thrown* in a world; this *throwmness* is an eruption that we cannot get behind to stand on some firm foundation. Our worlds are without ground, as Varela, Thompson and Rosch have emphasized. According to postmodernism, there is *a continual eruption of an ungrounded existence that finds itself in a world* plus *the continual eruption of texts into discourse*, where they may be appropriated.

In dreams, too, we are *thrown*, finding ourselves in a world, as Boss has discussed. Dreams spontaneously erupt into the dark night of sleep, whether REM or NREM, and we find ourselves thrown in the dream world. In our everyday existence, we have become insensitive to our throwmness into familiar worlds, but in dreams, where we may find ourselves in fantastic bizarre worlds, the throwmness of existence is easily evident. *Dreams highlight our postmodern throwmness.* Nothing throws us better than the dream work.

Not only do we always already find ourselves thrown in a world surround, we are *always already situated* as we go about our daily business. We operate within a pragmatic horizon. That situatedness continually changes, as our drives and feelings fluctuate, as our intentions and projects shift, as our meanings are succeeded by new meanings. Everything is *in movement*, as the preSocratic philosopher, Heraclitus, taught; there is movement of the input flux from the world surround as well as our fluidly shifting situatedness. *We flow; discourse flows. Dasein has a streaming existence.* This movement is not the computation of logical thinking. Such a flowing dynamic is thoroughly postmodern. (Cf. Derrida's [1982b] *différance* and Heidegger's [1972] *Ereignis*, discussed in chapter three.)

Let's consider our flowing situatedness in relation to dreams. The ordered input flux ceases by and large during sleep and is replaced by a random perturbation coming from pontine centers, so what remains of the flow is a flowing situatedness. Dreams provide a case where sensory constraint from the world is generally absent, so we can see more clearly the effect of our situatedness. *Dreams reveal our flowing postmodern situatedness left over from waking life.* We do not lose our waking situatedness in dreams; to the contrary, the situatedness left over from waking, unopposed by sensory input, is released to unadulterated expression.

This is to say that in dreaming we are situated just as in waking. We may be situated fearfully and have a nightmare. For example, after an encounter with a rattlesnake that really rattled me, I felt very vulnerable; I was situated in

vulnerability. That night I had a recurrent nightmare in which there were sinister forces out to murder vulnerable me. My residual situatedness created my dream reality. Or we may be situated desirously and have a wish-fulfilling dream that would gladden Freud's heart. Our situatedness varies between dreams and within dreams. Recall the peculiar disjointed character of dreams: we are thrown in one world, and then suddenly we are thrown into a different world. Such thematic discontinuities are produced by partial shifts in our situatedness while dreaming. *Dreams have both the fluid situatedness and fragmented quality that is so characteristic of, and maddening about, postmodernism.*

4. The dreamer and the dream

Since postmodernism is anti-rational, it might seem that Freud is one of its progenitors, with his emphasis on the illogical unconscious mind. But Freud's theory of dreaming is highly modernistic. His science, rooted in Newtonian physics and classical thermodynamics, is inevitably modernistic.

For Freud, meaning *precedes* dream imagery; there are unconscious dream thoughts that underly the dream. The dream work translates these thoughts into a predominantly pictorial representation, which is the dream. In dream interpretation, Freud held, we recover the original language—that is, the unconscious dream thought—from its pictorial representation. The essential modernistic duality here is between a dreaming subject, who has meanings and thoughts, and the dream text that *expresses* those meanings and thoughts.[3]

For a postmodern view, the dream has no author. There is no dream subject or enlightened intelligence trying to tell us anything, however useful that fiction might be in clinical situations. No message is sent from the unconscious. There is no meaning held on the one hand, which is expressed in hidden fashion in the dream text on the other hand. Nothing and no one thinks the dream: *the dream is a text that spontaneously erupts within a horizon of residual meanings, feelings and motivations.* That nondual *Ursprung* is thoroughly postmodern in spirit.

5. Dream rapture

There is another very important characteristic of dreaming (at least in the tradition of the technologically advanced west) which Rechtschaffen called "the single-mindedness and isolation of dreams." Our attention may be *held rapt* in dreams; we are enraptured, fascinated by the goings on, so much so that we typically do not step back and reflect on the dream. (In some dreams we are detached, it is true, but even here our detachment is often single-minded in the

face of fabulous dream events.) That is, *enrapture and reflection are polarities.* Enrapture typically dominates dreaming, and reflection may dominate waking. Of course, in lucid dreaming our reflection may surpass that of waking, but this is exceptional. Dreaming is ordinarily non-reflective, whereas reflection is a common occurence in waking.

The etymological root of "rapt" is the Latin *raptus* which means "to seize." The afore-mentioned eagle, together with the falcon and the hawk, are of the class of *raptors*, birds that seize their prey. Raptors are emblematic of the dream; we are seized by the dream events. Save for occasional instances of lucidity, we are incapable of reflecting that "it is only a dream." We are unable to step back and watch the dream with interest. Instead we are caught in the talons of the dream life, and we are carried away from our ordinary world. Truly, the eagle is the spirit animal of the dream.

The significance of dream rapture has not been fully appreciated, especially since we have become intrigued with its opposite, dream lucidity. Not only does the sensory constraint cease in dreaming, but reflective reason, by and large (though not invariably), slips away in dreams. What typically remains is total immersion in the life-world of dreams. In dreams we are, unless lucid, at the mercy of left-over meanings, feelings and wishes that happen to be the existential condition of our lives at the time of sleep. *We are seized by the world these residua create.* It is different in waking life only in degree. In waking, too, we are seized by the world our situatedness creates, although this captivity is obscured by the input flux and reflective reason. The world thus created in dreaming is not a leftover world of the past, as Freud thought, but a completely new world emerging from our present existential condition. *It is our situatedness that is residual, not the world that results.*

So dreaming is typically nonreflective in that the self-appropriating character of waking is lost. In waking, self-appropriation can become so aggrandizing that all immersion in experience is lost; taken to the extreme, this is a psychopathological condition. The person with this condition is typically not absorbed in experience but is always watchful of experience, always contextualizing and recontextualizing experience, and thereby feeling disconnected from the world and other people. These patients feel uncomfortable with and distant from others. Part of their attention is always caught up in observing themselves. Such common clinical conditions are the opposite of dream rapture in which experience is not contextualized.

Dream rapture is emblematic of another postmodern strand. Heidegger (1962) critiqued the detached, reflective attitude toward the world as artificial. (Gibson [1979] posed the same criticism some fifty years later, with respect to the artificial conditions of laboratory studies in perception.) Modernity, with its rationality, gives primacy to objectivity: so cool observation and reflection are its characteristic methods, idealized in the white-coated scientist.

Postmodernism, in contrast, emphasizes intense involvement, immersion in the world. We are situated in the world with our purposes and plans, doing this and that. World objects have a "ready to hand" (*Zuhanden*) quality. These objects are pragmata ready to be used; world objects have the character of equipmentality, affording this and that usage.

We are fascinated by our waking projects. We *care* about things, care about what happens. Everything matters. Care is ontological: it is integral to our existence that whatever happens matters. Even for the borderline patient, for whom nothing matters, it matters that nothing matters.

Because of modernity's commitment to detached reflection, the powerful role of *waking rapture* is not appreciated. We dismiss waking rapture when we say that we should not let the heart triumph over the head. Or, in reaction to rationalistic modernity, romanticism maintains that we should listen to our hearts and forget our heads. But both rationalism and romanticism miss the deeper significance of our waking rapture, the "care" that permeates our waking being. The eagle is the spirit animal of *both* waking and dreaming, where we are seized by the worlds our meanings create. But it is in dreams that we can see this most clearly since here "care" is shown in purest form, unopposed by reflection. *Dream rapture is thus emblematic of the postmodern emphasis on "care."*

Such rapture—our seizure by our own meanings—is of profound importance to the fate not only of individuals but to the fate of cultures, societies and nations. The world community is continually seized by the eagle, by the worlds that meanings create, worlds in which conflict and violence seem natural. The point can never be driven home deeply enough that we are captive of our meanings. To be so captivated is the human condition. Typically, this captivity is transparent; we do not notice it as we live it.

6. "Reality"

It has been shown above that our thrownness in the dream world and our dreaming rapture are deeply emblematic of the postmodern construal of the human condition. But this by no means implies that postmodernism has appreciated the full significance of dreams. In fact, a consideration of dreams forces a drastic revision of postmodern realism.

Now "reality" is properly a philosophical term that we should use most gingerly, even though we throw it about in everyday conversation. The term "reality" has multiple meanings that are all mixed together. To further complicate things, our language is structured such that we only have dualistic subject-object ways of speaking. This forces Derrida to use dualistic language

sous rature (under erasure). So every time "reality" crops up in the following text, eyebrows need to be raised and the eraser kept handy.

Postmodernists are staunch realists. The world is there before us, just as we think it is. We do not know reality, according to postmodernism, by means of any re-presentations of that reality. We know reality directly and immediately; there is nothing that gets between us and the reality we always already find ourselves in.

Modernity, in contrast, relies on representations of the world—mental and neural re-presentations that mediate between us and world. Not only does the theory of re-presentations contradict our experience, it introduces, according to postmodernism, a duality between re-presentations and reality, between inside and outside, immanent and transcendent, subject and object, spirit and matter...a panoply of dualisms.

Let's consider the consequences of the postmodern rejection of re-presentations of the world when we turn to dreams. Modernity appears to have an easy time explaining the dream world. (For a critique that explores the fallacies of this explanation, see Globus [1987a].) The dream for modernity is just another re-presentation of reality, put together by means of compositing *memory traces* that re-present reality, instead of the *on-line* re-presentations of reality that characterize waking perception. Because the memory traces are of different times and places, the reality re-presented in dreams is bizarre and fantastic. *From Freud (1900) to Foulkes (1985) and Hobson (1988), the dream is thought to be constructed from memory traces of the waking life*, although they differ about what memory traces are.

This modernistic dream theory cannot be entertained by postmodernism, which has given up re-presentations of reality during waking. Dream reality is indistinguishable from waking reality, at least in the living of it, whatever we might be able to figure out later during waking reflection. Dreaming and waking realities are *indiscernable* in the living of our lives. Indiscernables demand the same explanation. How, then, is postmodernism to explain the dream world, without admitting on an ad hoc basis previously repudiated re-presentations in the form of memory traces?

In my book *Dream Life, Wake Life*, I have attempted to explain where the dream world comes from by saying that all possible worlds that we might ever perceive, in waking or in dreaming, are *always already available within the brain as possibilities*. The form of these worlds, however, is not the ordinary form of *explicate* reality, not in the form of the world unfolded before our very eyes, not this world here now. These possible worlds within the brain take the form of what I called the *holoworld*. *The holoworld enfolds all possible worlds*; these worlds are interpenetrated *implicate* orders. (The distinction between explicate and implicate orders is David Bohm's. What is called here the "holoworld" is formed by a brain process and is not equivalent

to what Bohm calls the "holomovement," which is a fundamental physical process.) In both dreaming and waking, we explicate (unfold) worlds out of the implicate orders of the holoworld. *So both waking and dreaming worlds come from the same place, from the holoworld, by explication of implicate orders.* Dreaming and waking worlds are at parity.

7. Brain mechanisms

Let's next focus on *how* the brain unfolds waking and dreaming realities from the holoworld of possible worlds. Here the language shifts to concrete, untroubled, scientific talk of neurons, excitation, inhibition and the like, rather than metaphoric locutions such as "eruption" and "rapture." It would be a postmodern fervor that would deny altogether the validity of scientific talk. Indeed, such an insistent fervor is modernistic in its demand for continuity and its absolutism. My text instead fragments in the turn to brain mechanisms, presenting a surface of broken complexity.

Neurons, systems of neurons, and systems of neuronal systems, all mutually influence each other at various levels. (This nested character of neural organization, where systems are contained within systems, is called "recursion.") Influence between recursively organized systems is excitatory, inhibitory, or modulatory. By "modulation" I mean that there is a *tuning* of system parameters so that excitatory and inhibitory influences are *constrained*. Excitation, inhibition and tuning are key concepts for understanding brain functioning.

Given the crucial role of excitation and inhibition, polarity is the basis of brain functioning, not information processing. Neural systems oppose each other. But this should not be conceived of as a kind of war, since these polar systems are committed to resolution of conflict, to finding a settlement that satisfies all parties. The society of recursively organized, tuned neural systems excite and inhibit each other until some kind of stable community consensus settles out of the self-organizing process. The resulting harmony lowers the energy of the whole system. In physics this is called the principle of least action for dynamical systems,[4] as Yasue has discussed. Dynamical systems spontaneously self-organize so as to maximize consensus, harmony, symmetry, elegant simplicity, goodness, self-consistency, *resonance*. All these terms that describe the system's settlement give an intuitive sense of the mathematically formulated, physical principle of least action. The terms "resonance" and "harmony" will be used more often than "least action" in the following, since they are so intuitively familiar to us from listening to music and other sounds.

This recursively organized brain system flows along, changes states, and rapidly settles into a particular state for awhile, until conditions change, and the

system begins to self-organize again, until a new settlement is quickly reached. The settling time is on the order of a few tenths of a second; the series of settlings and settlements segments the flowing process. The process of settling and reaching settlement keeps going, and going, and going. The settled process starts up again when conditions change.

One powerful change of condition is a shift in sensory input, which perturbs the brain system. *The brain resonates to sensory input*, achieving a harmony with it. Another change of condition is due to tuning, as a function of motivation, emotion and cognition. *Tuning modulates the excitatory and inhibitory influence*, e.g., by controlling the extent to which an action potential invading the output axon of a neuron penetrates the axonal arborization, or by initiating bursts of excitation or inhibition. So the brain system is perturbed by the input flow and variously attuned. The flow of brain states accordingly becomes segmented and punctuated by settlements.

It is crucial to appreciate here that this flow of settlements is *not* obtained by taking a settlement and logically transforming it to another settlement. That would be information processing. Instead, each consensus settles out of the whole; these harmonies are continually generated by the whole, by global processes. *There is primacy of the whole; the brain is holonomic in its functioning.* Instead of the local transformations of computation, step by step, there are the continual global settlements of the dynamical system.

This result, that brain settlements are continually generated holonomically, rather than by transformation of other brain settlements, is the key to understanding the connection to the theory of the holoworld. The rich interactions between neurons and neuronal systems continually form a whole, a holoworld, that each moment enfolds rich possibilities. And at each moment there are influences on the whole system by a variety of inputs that variously excite, inhibit and tune. A world settles out, waking and dreaming, under the principle of least action. The difference between waking and dreaming conditions is that in dreaming, sensory influences and the influence of reflection drop away, leaving unopposed the constraining influences of wish, affect and meaning.

It follows that we don't need to have a world out there to perceive a perfectly authentic world; all that is needed for a world to settle out is the dynamically evolving, self-organizing brain system, and this does not require input. The world perceived in both waking and dreaming is a *brain achievement*. The world does not stand apart on the input side. Nor is the world produced on the output side, like Plato's Demiurge produces the cosmos out of chaos. (I at times speak of "producing" and "creating" but these terms are used *sous rature*.) There is no little world synthesized inside the brain, which some little homunculus perceives. There is no re-presentation of the world. There is

only one world, the one we perceive, the world our brains achieve, both waking and dreaming. The brain's achievement is a flow of settlements which provide the Jamesian stream of consciousness. *What it is to BE the brain achieving those settlements is to find oneself situated and thrown in a world.*

8. The world as irreality

It is distressing that the world as we ordinarily think of it is illusion, *maya*. We hoist the world in waking, just as in dreaming. This world here now is but a dream. This all sounds very familiar from the perennial philosophy, but the transpersonal movement is still partially caught up in modernity and doesn't understand the doctrine of *maya* radically enough, it seems to me. The transpersonal movement typically doesn't see that the world of waking is "just a dream" in a very deep sense. Many transpersonalists think that the world really is there in some true way but we keep misinterpreting it. Free ourselves from our distortions, they think, and then we can view reality in shining truth. Other transpersonalists think that the world is pure illusion; the real is nondual, distinctionless. The present claim is different: The world is not out there in the way that we think in everyday existence. The world *in its apparent out-thereness* is a brain achievement. *The world that we always already find ourselves thrown in continually settles out of a spontaneous eruption.*

Of course, transpersonalism is quite capable of outright disregard for anything having to do with brain achievements, in the mistaken idea that mixing transpersonal and brain talk is reductionistic. This is mistaken in that the point of mixing transpersonal and brain talk is to find semantic resonance, not to reduce the transpersonal to the biological. Or else brain achievements seem irrelevant to transpersonalism, given the primacy of the nondual. But there is no state of enlightenment without a functioning brain, no freedom (*moksha*) unless there is intact neuronal activity, and this lets the camel's nose into the tent. Unless we remain completely silent, in evocation of nonduality, the brain must be factored into any discussion of nonduality. But brain science opens to all science, so a bridge between transpersonalism and science is open, save for the closure of a vow of silence (a vow mainly honored in its breach, given the perennial outpouring of transpersonal writings).

This world here now that we all seem to share by being in it is not a common world outside our skins but is multiple, entirely inside our individual brains. We are, in a sense, monads that procede in parallel. As Castaneda's (1972) sorcerer Don Juan says, each of us is a "bubble of perception." If we have the same input and have learned the same description of the world, then our bubbles of perception light up in the same way. But if we learn to change our description of the world and adopt, say, the sorceric description of it, that

is, if we cast off our ordinary world description and enter the unfathomable *nagual*, as don Juan terms it, then all possible worlds are open to us through spontaneous creation. Together with our fellow sorcerers, all having a similar predilection, a world of immense mystery, power and beauty is hoisted through our unrelenting intent.

There is something else we have lost, besides the world. We have lost our selves, too, the selves that we thought were primary and autonomous over against the independent world. But we find ourselves also achieved, always already thrown in the dynamical creating. Both subject and object are *derivative* of a primary, nondual movement; subject and object are brain achievements that settle out of a global, dynamical process. So we have lost that which is comfortable and familiar, indeed, both our world and our selves. The gain is that subject/object dualism no longer infects fundamental ontology; this dualism is derivative, coming out of a spontaneous, dynamical eruption that is itself nondual.[5*]

O terrible isolation! How humbling! What Sartrean nausea overcomes us! The world in which we believe, which we cannot help but believe in, and ourselves in that world—all this, self and world, both waking and dreaming, is secondary, achieved in a dynamical movement. The world is not something autonomous, over against us. We-and-our-world, our thrownness in the world, is the settlement of a brain process. When we cease to give waking ontological primacy over dreaming, and appreciate the full philosophical importance of dreams, then—Ah!—we are such tenuous beings and so alone![6*]

This view should not be mistaken for a solipsistic antirealism. "Reality" here is not the world in the midst of which we are thrown, as it is for Heidegger. Reality is completely dark, yet knowable in a certain way, even though it is nothing, no thing. We know this reality through our resonance with it, as we come to harmony with the input constraint. Truth lies in the elegance of the resonance; harmony affirms the unseen reality. We are self-tuning systems and, accordingly, are attuned in a certain way as we intersect with "reality" (with T.S. Eliot's "O hidden," with Heidegger's *Es* that gives being and time, both quoted in the epigraph). Out of the convolution of "reality" and our attunement, the brain begins to resonate in a certain way that is, ideally, perfectly coherent with "reality."

This position deviates from the mainstream of postmodernism which is highly relativistic. All truth is contextualized in the usual postmodernism. The present appropriation of postmodernism holds that when we are open and resonating with reality, *when we are emblematic of reality*, then we are "in truth." The catch is that we have no direct acquaintance with that which we are emblematic of when we are "in truth." And since our attunement keeps flowing, with continual recontextualizations, a final, canonical "being in truth" can never be attained. We are ever on the way.

Of course, our attunement is typically such that a certain dissonance remains in the intersection with "reality." One way of looking at the meditation disciplines is to say that the mind/brain is being trained so it can freely "resonate" to "reality." When maltuning is corrected, our existence becomes emblematic of the "real." (I shall drop the eyebrow-raisers around the term 'real' hereafter.) But ordinarily fallen into *Samsara* and maltuned, the emblem is distorted. And, as has been emphasized, we are never directly acquainted with what this emblem is emblematic of; we only have the emblem.

This view is distinct from the transpersonal idea that when we free ourselves from distortion, we attain true reality. We can never directly contact reality; we only have reality's emblem, which may attain a high degree of symmetry with reality. This view is also different from the transpersonal idea that true reality is distinctionless. The structure of our resonance implies that reality has structure, an order that we know through our resonant structure. Although we do not re-present the world, we do, in a sense, re-present reality in virtue of our resonance with it, under the principle of least action.

9. Discussion

Postmodernism is a paradigm change that deconstructs the tradition of modernism, with its rationalism and logic, mental and neural representations, dualism, essentialism, and grounded, eternal truths. This tradition has been shaken by postmodernism, even though some modernistic residua persist in postmodernism.

The dream is an exemplary expression of the postmodern. The dream *erupts* into the dark night of sleep; a dream existence *spontaneously erupts*. The eruption of our thrownness in the life-world is very difficult to discern during waking. Four hundred years of modernism never came close to it. In dreaming, the *Ursprung*, the eruption, of postmodernism is evident. In the eruption of the dream, we are seized by the world our meanings create. Dreams show in pure form our human proclivity for rapture with our own products, which is the ultimate narcissism that is the curse of the human condition. Perhaps the brain's spontaneous, self-organizing movement toward states of harmony under least action is emblematic of a far greater dynamic, the self-organizing movement of the cosmic whole toward symmetry, self-consistency, resonance. This movement toward harmony is also emblematic of the consensus, the peace, toward which individuals, communities and nations should evolve.

The present aim has been to think together "postmodernism" and "dreaming," hoping to open up such discourse. Dreaming is of immense importance for the understanding of the human condition, so any new paradigm is obliged to explain dreaming. One of the great mischiefs of modernism is the

domination of waking over dreaming, whereas postmodernism, in the present appropriation of it, calls for full parity between waking and dreaming. Postmodern realism in which we are thrown into an actual world cannot be sustained, given this parity; subject and object, self and world, are seen to be derivative of a dynamical self-organizing, nondual, holonomic movement, during both waking and dreaming.

Human understanding was eventually able to grasp and to withstand the Copernician revolution that decentered humanity in the cosmos, eventually able to absorb the Darwinian revolution in which humanity's lofty separation from the beasts collapses, eventually able to embrace the Freudian revolution that dethroned reason, undermining *logos* from below. Unfortunately, the prognosis does not seem good for our relinquishing our world as reality. The doctrine of *maya* and its equivalents date back to antiquity, and still we cannot help but experience this world here now as real. We can never get behind or below or beside our thrownness, never get prior to being and time. We can only accept the facticity of our world thrownness and hope to transcend the illusion that is the world by proceeding with empeccability and by entering states of nonduality. Dreaming provides the wedge that opens our perilous postmodern human condition in which world and self as primary realities are lost.

APPENDIX

REPORT BY REVIEWER #2

One of the vexing problems with this interesting paper is the strangely out-of-date, doubled essentialism of its strongly high-modernist position. This is starkly revealed by the author's use of the definite article "the," viz., "the dream is an exemplary expression of the postmodern." The irony here is that both "the multiplicity of dreams" (see Harry Hunt's excellent book by that title) and the many postmodernisms are by now quite well known to the general, educated public. Also, "postmodernism" is defined as a "controversial movement in contemporary thought." This is only partly the case since postmodernism is also the historical moment following modernism that we are all sharing today.

As the essay now reads, it appears that the author has just recently discovered postmodernism—or better yet has just begun to read Heidegger and Derrida—but has not yet read Nietzsche, Foucault, Wittgenstein, Rorty, Lyotard, or Lacan. Catch-up-ball is now in order. Perhaps this reading should begin with phenomenology so that instead of re-inventing well-known concepts (i.e., "self-appropriating" for Kristeva's "intertextuality"), the author can cite the appropriate sources.

There are several other problems with the essay. For example, what is "the perennial philosophy?" Sounds insulting to the entire field of philosophy. Secondly, the use of informal street language and other oral markers comes as a jarring note in the midst of the high-modernist object language. The frequent use of italics throughout the essay is not only unnecessary but also insulting to a reader in that s/he will decide for him/herself what is important and what is not in a given paragraph. Bold feels like yellow-highlighting to me.

Finally, the use of the mythic "Don Juan" as the prototype for a "sorceric description of the world" is simultaneously out-of-date and an insult to the many years of painstaking scholarship, mentorship, and apprenticeship engaged in by several generations of Native American shamans and their students. Perhaps some reading of legitimate Native American sources on shamanic and sorceric world views would help.

I guess my main problems here are both with the lack of preparation for such an elegant sweep of so many fields and with the overall tone of the essay.

CHAPTER EIGHT

TAKE-OFF TO QUANTUM BRAIN DYNAMICS: THE EXCISION FROM DISCOURSE

> ...everything here passes and fades. The essence of this architecture is movement synchronized towards a precise objective. We observe a fraction of the process, like hearing the vibration of a single string in an orchestra of supergiants. We know, but cannot grasp, that above and below, beyond the limits of perception or imagination, thousands and millions of simultaneous transformations are at work, interlinked like a musical score by mathematical counterpoint. It has been described as a symphony in geometry, but we lack the ears to hear it.
>
> Stanislaw Lem, *Solaris*

Although the scientist in me longs to summarize the essential points of my text in this final chapter, my acquired veneer of postmodernism prevents such a conventional conclusion. Instead the text bifurcates sharply to what Yasue calls "quantum brain dynamics" (QBD), in which brain functioning is viewed in quantum physical terms. QBD, I think, is the leading edge of a progression from neural network theory (which remains computational, like its classical information processing predecessor), to the nonlinear dynamics of complex brain systems (as developed above), to formulations in wave terms, where quantum nonlocality becomes operational. The text of chapter eight is incomplete and toward the end begins to break down and fragment, disrupting the smooth, lulling continuity valorized by modernity. The text does not close off but speeds up and ends with the openness of a colon (to indulge in some droll Derridean polysemy).

The incision of this chapter is through a critique of the theory that the brain processes information, but now from an empirical standpoint quite different from the above deconstructions. This critique is from within brain science, and claims that the conventional paradigm doesn't even deal with its own empirical findings properly; that is, the emperor has no clothes. The remainder of the chapter focuses on QBD, knowledge and language.

1. An empirical critique of brain information processing

So prevalent is the information processing theory and so prima facie plausible, that a "knock-down" argument is probably impossible. In any case, the more limited goal of this section is to show that this theory is not especially compelling. Kuhn has well-described the resistence of scientific paradigms to change and the strain of the attempt to encompass anomalous data. This can be seen in recent treatments of the famous Hodgkin-Huxley equation, which is at the heart of the information processing view.[1] This equation describes the input/output transfer function at the neuron. Recent discussions of the Hodgkin-Huxley difficulties strain to rescue conventional views from empirical findings and from the results of computer modeling of brain functioning. We shall see that there can be relaxation, once the information processing idea is relinquished.

Some problems with the Hodgkin-Huxley equation

Softky and Koch show that neurons with Hodgkin-Huxley transfer functions should fire regularly to input, but this is not found empirically. Cortical neurons in certain visual areas of the awake macaque monkey responding to visual stimuli do not fire regularly; in fact, they show large interspike variability. Since neither the data that Softky and Koch use nor the model is controversial, they conclude that

> the present knowledge of pyramidal cell biophysics and dynamics is unable to account for the high CV [dimensionless coefficient of variation] seen in fast-firing monkey visual cortex neurons: *these cells should fire regularly, but do not.* (Softky and Koch, 1992, p. 645, italics added)

The *near-random* spiking of these neurons is "inconsistent with their assumed role as devices that temporally integrate over many inputs" (p. 645).

The conventional information processing view can be rescued, however. If strong synaptic conductance changes create a very fast effective time constant, or if nonrandom synaptic input is highly synchronized on a millesecond scale, then the Hodgkin-Huxley model would be compatible with the large interspike variability observed. So Softky and Koch's final point is that "it may well be that the time scale of cortical computation is much faster than previously realized" (p.645). Thus, faced with the failure of the Hodgkin-Huxley equation, which would undermine the whole information processing enterprise, these authors are prepared to revise highly plausible and well-established views in order to save the theory. They do not pick up the naked

alternative, which holds that if cortical neurons fire near-randomly, then the brain must be doing something other than processing information.

Strassberg and DeFelice point to a different limitation of the Hodgkin-Huxley formalism. Active neuronal membrane contains discrete channels that connect the inside of the neuron with the extracellular synaptic space. When a channel is open, ions flow back and forth between the intraneural and extraneural spaces. These ion channels undergo random fluctuations between the open and closed states.[2] Strassberg and DeFelice's simulations suggest that under certain conditions, random fluctuations (noise) *in even a single ion channel* can generate an action potential. They comment on such spontaneous action potentials produced by a random event.

> Within the published neurobiological literature, there is a conspicuous dearth of information regarding spontaneous action potentials. Much of this is the result of a common bias that the phenomenon of spontaneous action potentials carries no useful information and thus has little physiological significance. Published data tends to concentrate on the "representative" response of the neuron and to deemphasize the stochastic nature of neurons by routinely excluding raw, unprocessed data in favor of averaged data trials, which show much less variability...With the current absence of any strong consensus on how the nervous system encodes information (beyond the level of sensory transduction) one is unable to distinguish strongly the "signal" from the "noise." (Strassberg and DeFelice, 1993, p. 853-854)

After thus indicating that stochastic data is suppressed by experimentalists and pointing to the lack of consensus on how information is actually encoded in the brain, a reasonable move would be to question that information processing is actually going on, but they instead try to save the theory by giving the empirically observed noise a role. "The filtering and averaging of data [by experimentalists] to remove the 'noise' thus may be removing important components of the data" (p. 854). "Noise" isn't mere useless noise, they suggest, but has important functional roles to play *as noise* (e.g., facilitating neurodevelopment). This is a possible conclusion, but not especially compelling. If neurons in the visual system fire near-randomly to sensory input and if random fluctuations of a single ion channel can produce firing, then it is also reasonable to think that the strict march of logical information processing may not be going on at such a place. There is just too much randomness present in a delicately poised system.

Problems with the story of the neuron

There is just too much information in the system, too, which can be seen if we take a birdseye view on the story of the neuron, rather than getting lost in the immense knowledge that has accumulated about neural functioning. The conventional definition of "state" is in terms of nodal outputs ("activation levels"), i.e., the action potentials initiated at the axon hillocks of the various neurons in the net and propagating into the axonal arborizations. (This dogma was unquestioningly accepted in previous chapters.) The action potential as a spike has an intrinsically binary character: the neuron is "on" or "off," depending on whether or not a spike is produced. This lends the information processing idea prima facie plausibility; the neuron seems to be communicating information in binary form.

On the input side we find small specialized regions at which graded changes in electrical potentials (postsynaptic potentials, PSPs) occur. Such graded events are distributed over the dendrites and the soma of the neuron. These graded potentials are connected to axonal output by a transfer function. In simplifying models, the graded potentials are merely summed to form a "generator potential," and when the generator potential reaches a certain threshold, a spike is initiated. Thus the input information at the many synapses is thought to be integrated and converted to binary output information.

Let's now consider this input story in more detail and look for information. Imagine a semipermeable partition between two fluid compartments that differ in ionic concentration and electrical potential; that is, there are *electrical and concentration gradients across the partition*. Little channels made of protein pass through this partition. The channels have gates. These gated channels that stud the partition may be opened or closed, which gives the partition its semipermeable character. The channel gates are under neurochemical control, and also are controlled by voltage differences between the inside and the outside of the neuron. When open, various ion types rush back and forth through the channels down the fluctuating electrical and concentration gradients. In order to maintain electrical neutrality when sodium, say, flows in through a channel in the synaptic region, sodium ions flow out in an adjacent region. Thus ionic currents form and flow in *loops*; this flow is at a certain velocity and acceleration.

When we consider this detailed story, the notion that information is passing through these ion channels into the cell is not compelling or even plausible. By parity of argument, we would have to say that, because of the loops, information flows out, too. Furthermore, the tens of thousands of rapidly-changing ion channels for each neuron provide an overwhelming amount of information, which is then drastically reduced to a simple binary output by the transfer function. Such an enormous reduction of input is

peculiar, especially since the neat binary output supposedly expands back at the very next stage of "information processing" to large numbers of ion channels distributed over thousands of neurons. Information processing machines work nothing like this; they do not have a fan-in/fan out architecture. Since the ionic currents flow in loops, there is no justification for maintaining that one part of the loop is the information and relegating the rest to maintaining electrical neutrality. It is the loops of ionic current in the perimembranous region as a whole that now comes into focus, not what passes through the channels. There does not appear to be information processing going on here.

Let's continue with the more detailed story; we are still looking for manageable amounts of information which the conventional story calls for. At any time, t, there is a concentration of the different ions that varies throughout the perimembranous region. This ionic density distribution, ρ, results in differences in electrical potential across the partition, i.e., a transmembrane potential.

The partition itself is made of highly polarized lipoproteinous material, which is positive on the inner surface of the partition and negative on the outer surface. This lipoproteinous membrane is studded with channel proteins, as we have seen. There is a natural, ultra-rapid oscillation to the polarization at each point on the membrane, on the order of several picoseconds. This oscillation is represented by the variable, θ, which takes on complex values so as to represent the *phase* of the oscillation. So each point on the partition oscillates rapidly.

Change in the transmembrane potential causes conformational changes in these lipoproteins, whose effective charge thereby changes. This electrical change of the membranous partition sets up ionic currents in the perimembranous region, which flow down electrical gradients and pass through the partition, forming loops. The inner half of a loop passes through the ionic bioplasma just beneath the membrane, and the outer half passes through the extracellular fluid in the space between neurons. These ionic currents change the transmembrane potentials and, thus, the effective charge of the lipoproteins of the partition.

Thus, neurochemical release, which is a function of input, controls the membrane polarization and, thereby, induces the looping flow of ionic currents throughout the perimembranous region, which changes the ionic density distribution, ρ, which, in turn, affects θ. There is, accordingly, an *interaction* between θ and ρ.

If it were not for the conviction that the neuronal output is binary information and so what is going on at the input side must be informational, information would not come easily to mind here. Channels in the partition are opening and closing, ionic currents are flowing at certain velocities with certain accelerations in loops that pierce the partition, ionic density distributions are changing, and polarized membrane lipoproteins are oscillating—all these

processes are dynamically fluctuating and complexly regulated, in what would be an embarrassing surfeit of information, which, at threshold, by means of the transfer function, is supposed to be conveniently reduced to something more manageable, a single spike—and then information processing rushes on its way. Possible, I suppose, but not a compelling story. We best listen for other possibilities.

In addition, there is something strange from an informational perspective about the so-called "transfer function" between input and output: it is modulated (tuned). For example, the potassium currents are too small to make significant contributions to the rapidly fluctuating transmembrane potential, but they produce slow afterpotentials that predispose the neuron to fire in bursts. These neurochemically controlled potassium channels thus alter the transfer function. "The neuron and the synapse," Black (1991, p. xii) holds, "are emerging as unexpectedly dynamic entities that change from millisecond to millisecond..." This observation is at odds with the exact hardware of silicon information processing.

> Extensive evidence indicates that the brain is not an immutable series of circuits of invariant elements; rather it is in constant structural and functional flux. The digital computer analogy is fatally misleading. (Black, 1991, p.3)

Caught up in the prevailing paradigm, Black (p. xii) reconceptualizes "the very nature of neural information" in molecular terms, rather than give up the theory of neural information processing altogether, even when the result is that the hardware/software distinction is completely blurred (p.xiii). The exquisite neurochemical modulation of the transfer function should give pause to the information processing view.

Problems with the story of the brain's organization

In light of the excitatory and inhibitory, feedforward and feedback, connections of neural systems, it is certainly plausible to think that information is being sent back and forth between neural modules as part of a sequential process. Module M feedsforward information to N and N feedsback information to M. A more complicated feature of the brain organization, however, is "reentrant signaling" in which downstream information reenters upstream. Reentry is not simply feedback but is an "enormously diverse process" that depends on a variety of anatomical arrangements and various temporal properties, and leads to "a large number of ways of combining and recombining reentral signals."[3] But since there are typically reciprocal connections between a number of modules, rather than a series of modules with reentry back to earlier stages in the sequence, it is arbitrary to think of one connection as carrying the input signal and its

reciprocal connection as taking output and re-entering it. It is only because of our longstanding habit of beginning with sensory input and tracing its pathways in the nervous systems that we put current input before re-current input. Viewed more neutrally, we have a system whose modules are reciprocally connected. There the notion of a sequence with reentry falls away.

Consider the rich interconnectivity of neural systems past the sensory projection pathways: the complexity is such that there would be a staggering amount of recurrent information for the brain to handle. Among the 32 cortical visual areas that have been described, some 305 interconnecting pathways have been already discovered, constituting nearly one-third of the connections there would be if the 32 areas were fully interconnected. Instead of considering the possibility that there is just too much information interchange to be processed here, it has been suggested that this rich interconnectivity adjusts the exact nature of the transformation carried out within a given area, so that the brain is exerting control over its own computations.[4] This view, in effect, makes the brain *continuously self-programming*, which stretches the idea of computation beyond all recognition.

Here is another example of brain complexity: the posterior parietal and principle sulcal cortex are mutually interconnected with as many as 15 other widely distributed cortical areas—including anterior and posterior cingulate, supplementary motor, ventral and dorsal premotor, orbital prefrontal, prearcuate, frontal opercular, insula, superior temporal, parahippocoampal, presubiculum, caudomedial and medial prestriate.[5] Goldman-Rakic concludes that "higher cortical functions seem to be carried out by a finite number of dedicated networks of reciprocally interconnected areas"[6] and suggests "integrative functions may emerge from the dynamics of the entire network rather than from linear computations performed at each nodal point in the circuit."[7] The emphasis here shifts from local feedforward and feedback circuits that transfer information sequentially to emergent integrative properties of the whole.

The kinds of brain organization just described are, of course, in reciprocal interaction with other large brain organizations. Because of the rich interconnectivity, local regions of the neural organization quickly fan out to the whole and at the same time, the whole fans in on the local regions. This fan-in/fan-out relation between part and whole is characteristic at all levels of complexity in the nervous system's recursive organization. Input from the hyperneuron fans in on the neuron and fans out from it to the hyperneuron: that is the way the brain is built. At the other pole of complexity, there is the supersystem, denoted ψ, which consists of many systems and subsystems. The subsystems of ψ fan out globally, and through fanning in are globally influenced. Such a fan-in/fan-out architecture is not characteristic of computers.

For numerous empirical reasons, then, the idea of brain information processing is not certain or even especially compelling, and the way is open to consider other possibilities.

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So how does the brain do it? No one knows.
(Dreyfus, 1992, p. xliv)

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2. Quantum brain dynamics

Following Yasue, Jibu and Pribram, let's map the lipoprotein polarization of the neuronal membrane (or a group of neuronal membranes), θ, into a field, represented by an abstract plane.[8] Each point of the field represents an oscillating electrical potential at a point on the membrane; this potential is given on the third dimension. The oscillations are all equal in amplitude but vary in phase (i.e., are incoherent). The resulting surface of the field, which fluctuates over time, can be thought of as a very complicated wave form.

The wave form on the surface of a pond when a number of pebbles are thrown in varies in amplitude only; wave mixing is manifested as an interference pattern of amplitudes. The wave considered presently, in contrast, has its amplitude fixed at unity, and only the phase varies. Wave interference, then, is a matter of phase change. Such a wave is properly conceived in terms of a Gabor space. Here wave mixing is like the mixing of light waves, and, accordingly, has the nonlocality characteristic of quantum systems. The phase at each point of Gabor space is θ.

Recall that as the transmembrane potential changes due to input, the lipoprotein charge at the membrane changes, and perimembranous loops of ionic currents are induced, which results in a change in ρ, the ionic density distribution; conversely, the change in ρ affects the transmembrane potential, which affects θ. The state of the system, then, is defined by the product of θ and ρ. Input exerts cybernetic control on ρ through the input's effect on θ. Thus a complex-valued wave function under the control of input represents the state of the system, as Yasue, Jibu and Pribram show.

The mathematical procedure called Fourier analysis provides a transform domain where the space-time wave function just discussed is represented by a spectrum of frequencies whose phases are given by the Fourier coefficients. (We have assumed all amplitudes across the spectrum at unity.) Superposition of all the frequencies of the spectrum, at their respective phases given by the Fourier coefficients, reconstitutes the space-time wave function. Now when input comes in, neurotransmitter is dumped into the synaptic space, which opens up sodium channels, through which sodium rushes into the cell, thereby depolarizing the transmembrane potential at the synapse. In the succinct language of the Fourier transform domain, depolarizing (or hyperpolarizing) input shifts the Fourier coefficients. (Gabor space has dimensions for the Fourier coefficients.)

We have, then, a nonlinear dynamical system whose state is the neural wave function, ψ. The evolution of such a system is described by a wave equation—in the present case, the neural wave equation that describes the evolution of ψ. The evolution of ψ is not in virtue of logical principles, but reflects an *optimization principle*, as we shall now see.

In the mathematical representation of the neural wave equation, a certain quantity called the LaGrangean operator is minimized in the evolution of ψ. This quantity is a kind of energy that is being reduced, the "neural action." Minimization of the neural action is a version of Hamilton's classical principle of least action in physics,[9] which Yasue has extended to quantum dynamics.[10] Classically, the action is the difference between the kinetic energy of a particle and its potential energy, integrated over the path of the particle. The classical particle takes that path for which the action is least. (In optics there is a corresponding principle of least time that determines the geodesic path of light rays.) In the case of the neural action, the kinetic energy term depends on the square of the velocity of the ion currents, and (simplifying) potential energy is a function of input. When the LaGrangean is minimized, then the residual energy that is the neural action is minimized. (The residual energy is the energy remaining after the potential energy has been used up.) *Yasue's principle is that ψ evolves under least neural action.* The "precise objective" toward which the architecture of Lem's brain-like Solaris moves—see the epigraph to this chapter—is a state which minimizes the neural action.

An important characteristic of the neural wave equation, derived by Yasue, Jibu and Pribram, is that it has the same form as the famous Schrödinger equation in quantum mechanics. As in quantum systems, prediction of the evolution of ψ's states is in principle probabilistic (the functions are eigenfunctions). Thus predictive knowledge of the system is in terms of probable outcomes, rather than specifying the actual outcome.

Wave interference plays a crucial role in the neural wave equation. In Bohm's clear terms, the space-time order of the waves entering into the

interference pattern is converted to a *nonlocal implicate order*. Input order enters the nonlocal domain without leaving any trace; it becomes a distributed order, *hidden* within the whole because *interpenetrated* with other orders. So the distributed representation of input in the conventional neural net theory is, in Bohm's terms, implicate order, which is unlocalized in space-time (unlike billiard balls, say, which have a definite location). This nonlocal implicate order is to be distinguished from the ordinary extant, composited, explicate order. (For text, the explicate order is syntax, i.e., strings of meaningless marks on the page.)

Now under Yasue's principle, in which the LaGrangean is minimized, *symmetry is conserved and enhanced in the wave evolution*. Symmetry conservation is an immediate result of fundamental physical conservation laws of energy and momentum. In symmetry conservation, there is invariance despite flux; it is a symmetry in time. (Think of the invariance in the relations between the dancers in a Balanchine ballet, as the explicate patterns of the dancers change, certain relations between the dancers persist.) Under certain conditions, symmetry-breaking can occur and new symmetries form.

{Postmodernism is symmetry-breaking, which is experienced as a solicitation, a jarring shaking that results in some new symmetry. Postmodernism is poised at far-from-equilibrium conditions at the edge of chaos, ready to bifurcate to new symmetries.}

Symmetry enhancement is a different aspect of Yasue's principle; it is a dynamical symmetry in space between polarized others that form a "polaron." Symmetry enhancement is Heraclitean in spirit. A certain balance is achieved between excitation/inhibition, an optimized balancing of polarities in the polaron. (That is to say, symmetry is enhanced and conserved in the polaron.) In this balancing, the velocity and acceleration of ionic currents decrease to a residual minimum. (This leaves a residual ionic current flow to compensate for the remaining asymmetry.) The energy called the "neural action" is the energy of imbalance, of asymmetry in polarons. So under Yasue's principle, invariants are conserved and imbalance minimized (symmetry optimized). *Yasue's principle*, then, *insures both conservation of invariants and optimization of harmonious balance*.

It can now be seen how input "constrains" the evolution of ψ: By changing θ and thus ρ via neurochemical control of ion channels, different symmetries open up as possibilities for the system's evolution. We can think of the brain here as "resonating" to the input flux. Input constrains the system toward certain possible resonances, under Yasue's principle of least neural action. (A quantum physical analog here is the quantum jumping between electron orbits in Bohr's model of the atom. The "certain resonances" are eigenstates of the system.) At the same time the system's attunement constrains

the system toward certain resonances; brain resonance is a function of both input and attunement.

It is clear that Yasue and coworkers have developed a vastly different conception of nonlinear dynamical neural systems than the one that looks to axonal spikes as state-defining. To revert to the earlier language, *autopoietic, autorhoetic, nonlinear dynamical networks sustain an evolving wave that preserves and promotes symmetry under Yasue's principle*. The evolving brain states are best thought of as complex-valued wave flows. Constraints on the brain's evolution are elegantly represented by the Fourier coefficients of the wave spectrum in this formulation. The defining state of the network of neurons is a continuous wave function here, not pulses of binary information. As Pribram (1971, 1991) has long argued, we must look to the synaptic side of the neuron with its graded changes for the correlate of consciousness, not to digital spikes. (Pribram remains metaphysical, however, staying within the information processing paradigm, albeit the optical kind.) So instead of a series of representations on the input side, we have a continuous complex wave function with nonlocal properties, evolving under constraint according to Yasue's principle. With this formulation, the nonlinear dynamical brain system described in previous chapters takes on nonlocal implicate properties.

What, then, of the neural output? What role does it play that is not informational, yet which is consistent with its empirically determined randomness? The output aspect of the neuron remains a function of the input aspect, but neither is informational. Output is *influence*, not information. *The neuronal output is cybernetic*, exerting a measure of control within its sphere of influence, which overlaps complexly with other neurons' spheres of influence.

This cybernetic concept should be stated more sharply, since neurons are *both* influencing and influenced: At both input and output aspects of the neuron, we find *participation*. In fanning out to and influencing the whole, the neuron participates in the whole, and with fanning in from the whole, the neuron participates under the whole. Input and output here are linked via the familiar transfer function, but there isn't any information being transferred. The more the neuron participates on the input side through excitation, the more it participates (after modulation of the transfer function) on the output side. Conversely, inhibition decreases participation; the inhibited neuron drops out of participation. (Note that participation is restricted to excitation; inhibition is not a form of participation.) It is of no consequence that cell firings are stochastic here, since what is going on is participation by influencing and being influenced, rather than information transfer. The neuron sends irregular pulses of influence into its sphere of influence, via the axonal arborization, where it mixes with irregular pulses from other arborizations in the tangled neuropil. That the pulses of influence are irregular averages out over large numbers of participants.

Once we see that the transfer function doesn't transfer anything but controls participation, something else falls into place, the often blurry distinction between neurotransmission and neuromodulation. Neurotransmission is polarizing (de- or hyper-polarizing) at the membrane, thereby affecting ψ, whereas neuromodulation controls the so-called transfer function. (Neurochemicals do not necessarily cross-classify with neurotransmission and neuromodulation; the same substance may do both.) *Thus neuromodulation immediately controls participation, whereas neurotransmission immediately controls the state of the neural wave function.*

It is characteristic of the neural system just described that the part and the whole cannot be separated: they are mutually influencing. The continuous fan-out and fan-in interplay between part and whole can be broken only arbitrarily. The functional unit of the brain is thus not the neuron but the *neuron↔network*.

To the extent that information processing theory pervades our thought, it is easy to imagine a preferred direction in the loop between part and whole, Sensory input comes into the part, is *then* distributed to the whole, *and then* the whole constrains the part. Here the account is anchored in sensory input, in good empirical fashion. But there is no preferred direction; *the interaction between the neuron and the network is one undivided process, in which each operates on the other*. Sensory input enters in where and when it does, influencing this indivisible process, constraining its evolution to certain possibilities.

One way of grasping the present proposal is to approach it through "holism." I distinguish three types of holism: compositional, emergent and nonlocal. In the first type, the whole is a composition of local parts, like a string of symbols or a building; thus we speak of "the building as a whole." In the second type, the local parts interact so that the whole is more than the sum of the parts; here the whole has emergent properties. For example, think of the parts of the body whose inter-relationships bring about the emergent organismic properties. The third type of holism is characteristic of the quantum domain. Here there is interpenetration so that *there are no longer any parts*. Each part is enfolded to the whole, which is the interpenetration of all parts that gives the whole its nonlocal properties.

I just mentioned that with interpenetration there are "no longer" any parts. Another characteristic of the nonlocal whole is that there is an alternative state in which locality reappears. Indeed, there is a reversible enfolding/unfolding transformation between the local explicate order and the nonlocal implicate order, as Bohm proposed. This transformation has a peculiar property in that it is governed by Gabor's uncertainty relation: The more certain you are about the explicate space-time order, the less certain you can be about the Fourier coefficients that describe the nonlocal implicate order; conversely,

more certainty about these Fourier coefficients results in less certainty about explicate space-time. This uncertainty cannot be reduced below a certain minimum, analogous to Heisenberg's uncertainty relation. (See Pribram's [1991] discussion.]

3. Clark v. Fodor

There is a hard-fought ongoing battle over representation within the cognitive science camp that makes the present discussion appear irrelevant. Let's first attend to this controversy and later apply the present approach.

On the one hand there is the traditional view of computation, whose most prominent spokesperson is Fodor. Here we have concatenations of atomic symbols that can be substituted, rearranged, and transported according to logical rules. On the other hand, there is the connectionist view of computation; I choose Clark (1993) as spokesperson here, since he has provided a highly judicious defense and promotion of connectionism, and he critiques Fodor in some detail. (Of course, both hands are covertly joined in the commitment to computation.) It turns out, Clark shows, that Fodorism and connectionism (Clarkism) have reciprocal difficulties and successes. Since the mainstream, preoccupied as it is with the conflict, offers no alternative, the only solution for Clark is to work away toward some future resolution.

The Fodorian view, according to Clark, shines when it comes to folk psychology. Folk psychological explanations are couched in human belief-desire language (beliefs that..., desires that...). Concepts specify conditions of satisfaction for beliefs or desires, that is, a concept prescribes what will meet a belief or desire's conditions. This is all fine with the Fodorian, who holds that the symbol strings of language map to a neural language.

> The rule-governed combinatorial structure of familiar linguistic and logical systems and their exploitation of symbols is thus put forward as a model of at least the form of our inner computational life. (Clark, 1993, p.5)

Thus, when you intend to raise your left foot, there is a neural token—a meaningless syntactic form—that represents foot. This foot token is of the same type as when you intend to raise your right foot. So we might as well, according to the Fodorian view, just think of the brain code as concatenations of symbols subject to logical processing. The functionalist step is then easy: The concern is with an equivalence class, not the neural hardware as such, which can be left to brain science. So far, so good, for Fodorism.

The connectionist strength is different; it makes good use of the superpositional storage of distributed representations, according to Clark. (All

representations interpenetrate in the superposition.) Nonconceptual (nonlinguistic) categorization can be explained; so can prototype formation with graded judgments, prototype naming, and subtle context sensitivity. Connectionism fails, however, where Fodorism is strong. Connectionist prototypes are not transportable or combinable into concatenations of symbolic forms in the way that computation requires. Prototypes typically cannot play the role of content in complex expressions. Connectionist networks do not seem to have "the ability to entertain any one of an infinity of potential thoughts involving the systematic recombination of grasped meanings" (p. 108). Fodorian computationalism, however, has great difficulties in accounting for the prototype literature. The striking reverse symmetry between classical and connectionist successes and failures suggests a hidden coherence or collusion, a gnawing at different ends of the same bone, which I claim to be the commitment to information processing. Enter the constrained, nonlinear dynamical system evolving under Yasue's principle.

Attunement and constraint

The full taxonomy of attunement is an issue I shall defer here, confining my discussion to instinctual, emotional, nonconceptual and linguistic modes of attunement. When in the drive state known as hunger, the networks are attuned so that we perceive food, think about it, and take actions to attain it. In that state we typically find ourselves thrown in a world that affords food. In a state of depression, the nets are attuned for withdrawal, something to feel guilty about, pessimistic appraisals and the like, that is, attuned to confine the system to the more miserable regions of its state space, rather than the hungry regions (or both, in the case of the over-eating depressive). This is to say that in states of hunger and/or depression there are constraints on the evolution of the nonlinear dynamical brain system, constraints that are mathematically represented in the wave formulation by the Fourier coefficients. Given such constraints, the brain system evolves according to Yasue's principle of least neural action.

Instinctual and emotional attunements are genetically built in, prescribing a space of possible instinctual and emotional states. The limitations of this space are noteworthy: Though intense, the drive states and the affective states are relatively few. The space of possible knowledge, in contrast, appears to be unlimited.

Let's turn first to Clark's discussion of nonconceptual knowledge, before considering it as an attunement.

> The nonconceptual knowledge is the epistemological bedrock which puts the system in contact with the world its thoughts are meant to concern...But full-blooded thought ascription [the

> linguistic mode] imposes a further demand which requires the wider interanimation of a being's cognitive abilities. (Clark 1993, p. 70, bracket added)

To have nonconceptual knowledge consists in "being able to negotiate a certain domain." For example, a frog is able to negotiate a fly-infested domain, though presumably he lacks any concept of a fly. A human being is able to negotiate a social domain, for example, keeping a certain physical distance when talking with someone. This is accomplished without having any concept of the characteristic distance for holding a conversation in a culture—that's just what *das Man* does around these here parts—until someone gets up too close and discomfort sets in. (Violating the accepted talking distance is like the tool breaking in Heidegger's example, which discloses the context.) Nonconceptual knowledge is transparent in ordinary praxis for both man and fly.

It is in modeling nonconceptual knowledge that neural nets excel. Artificial nets can be trained up to find their way around artificial worlds. In the learning process, the connection weights are adjusted so that the net is constrained in its evolution in a certain way, resulting in certain behavioral acts. For example, Sejnowski's NETtalk is able to find its way around a severely limited linguistic domain, having learned to produce actual speech sounds when given written text.[11] NETtalk "reads" and "speaks" what it reads, through the adjusting of initially random connection weights during training on sample text. NETtalk's conversion of text to speech is based on nonconceptual knowledge.

Conceptual knowledge is very different, requiring a "wider interanimation of a being's cognitive abilities" (p. 70). More than just finding your way around some limited domain, conceptual knowledge involves a "whole web of concepts in which your concept of a fly is embedded," and further, "having your fly concept at the disposal of any other conceptual abilities you have" (p.75).

> Conceptual content...is structured content in which each element implicated in the specification of the thought has a separate significance for the creature and can enter freely into combinations with elements of the creature's other thoughts. (Clark, 1993, p. 76)

Concepts are elements of structured thought, and there is an "open-ended usability" (p. 86) of conceptual knowledge in a variety of cognitive episodes. But, Clark insists (p. 108), there are no convincing connectionist explanations of concepts as building blocks of structured thoughts, although he goes on to make a brave attempt. Clark candidly acknowledges at the end,

> Nothing in my treatment is sufficient to fully exorcise the ghost of full Fodorian systematicity...There *is* some mystery here, and it is not yet solved. (Clark, 1993, p. 224)

The Fodorian symbolic approach has an easier time with this issue. The conceptual content is naturally represented in language. This obliges the present discussion, which takes off from connectionism, to explain linguistic concepts in wave terms. This explanation, as we shall now see, radically revises the theory of representation.

Classically, representations re-present input information. The order of input is fully and concretely conserved in the re-presentation and/or abstractly analyzed. Such order is carried by irreducible and unchanging atomic components, the uninterpreted symbols or "tokens" whose arrangements comprise syntax. The transmission of information across a sequence of re-presentations is truth-preserving.

For the alternative developed here, "representations" are no longer information but are constraints, shaping the evolution of nonlinear dynamical brain systems. Nothing is re-presented; instead *there is a translation of something that is compositional to something that is nonlocal, with translation back again*. Fodor has no basis for insisting that the *process* of thinking uses local tokens; thinking might be nonlocal, even quantum physical, so long as a conversion to local tokens can occur.

No information is transmitted across a series of so-called re-presentations but symmetry is preserved and enhanced. What is "re-presented" is symmetry. Given a certain symmetry, the system's evolution is confined to certain regions of state space, unless bifurcation occurs. Thus, *a syntactical pattern is converted to a constraint within a global symmetry-preserving and symmetry-enhancing system and is reversibly converted back again.* The syntax↔constraint dyad is irreducible in the conversion process.

The re-presentation here becomes a transportable, removable and substitutable symmetry. The concept of foot can be moved around, so to speak; its symmetry constrains whatever it convolves with. But "move around" should really be understood as participation in different contexts, not as entering new compositions. The various settlements of the participating neural nets are then converted back into syntactic presentations by the motor system. Thus we have an irreducible dyad of local-syntactic and nonlocal-semantic.[12]

The local neural syntax should not be confused with the signifier, which Saussure explicitly thought of as a sensory image.[13*] The signifier is a settlement (chapter two, p.14). Thus in reading a text, the input order is transduced and processed, resulting in a local neural syntax. This syntax is converted to a global constraint on the evolution of the visual system, which settles into a state in which a signifier is perceived. At the same time, the local neural syntax is converted to a global constraint on the evolution of the language system, which

is the signified. Thus signifier and signified are not at all like two sides of a sheet of paper, as in Saussure's image; the signified is a global constraint whereas the signifier is a settlement. Nor are the neural syntax and the signified like the two sides of the paper, since the latter is nonlocal.

Thinking is a matter of tuning language systems, which are decoupled from expression in speech or writing. The evolution of thought is the evolution of a nonlinear dynamical linguistic system that is capable of outputing syntactical strings, but doesn't, unless we are thinking out loud or writing our thoughts down. Practical thinking is not that logical. One knows how to think about things—how to think about planning a vacation, say—without following any explicit rules. Thought is constrained here by feelings and fantasies, drives, expectations, goals—all manner of constraints—and a line of thought settles out, which might be coupled to expressive systems and thus said or written down. So the line of thought is always on the verge of syntactic expression. In formal thinking, the constraints are hard, and ideally, there is only one trajectory of attractors. Practical thinking, in contrast, permits a multiplicity of thought trajectories.

So there is a way for connectionism and nonlinear dynamics to explain conceptual knowledge. Conceptual knowledge, like non-conceptual knowledge, is non-local (quantum physical), but unlike non-conceptual knowledge, it is convertible to language, which is derived from the settlements of the conceptually constrained, nonlinear dynamical system.

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We have already seen that there is a problem with the conventional view of the transfer function, in that cortical cells should spike regularly, but do not, and a random opening of a single ion channel can elicit a spike. Perhaps the whole idea of the transfer function needs to be overhauled in a radical quantum way. Here is a considerably watered-down version of Jibu and Yasue's account (in press) of the "transfer" of input to output, which takes place via a quantum domain.

We have focused above on the perimembranous region through which ionic currents flow in loops via membrane protein channels. There is another system that fills both the intraneuronal cytoplasm and the extraneuronal synaptic cleft, a sheaf of single-layered protein filaments. Intraneurally the sheaf is commonly called by the misnomer "cytoskeleton;" bone is too static an image, so the alternative term "microtubules" is better. Extraneurally, the sheaf is called the intercellular "matrix." The ultramicroscopic filaments inside and outside the neuron have multiple links by hydrogen bonding (where two filaments share a hydrogen atom). So we can think of *a second nervous system*

categorically distinct from the familiar system of neurons. This second system is *a web of ultramicroscopic filaments that disregards neuronal boundaries*; the ultra-neuropil is a web of proteinous filaments. There is an interaction between ionic currents flowing in the perimembranous region and the filamentous web. So now we have interposed between the neuron's input and output a new kind of neuropil with remarkable properties, as follows.

The filamentous web must be treated as a quantum physical system. For physical reasons, the web is segmented into 50 micron regions. A 50 micron region undulates with quanta of energy called "bosons." Darvdov solitons traverse the filamentous web. (Solitons are propagating, wave-like phenomena requiring little energy that form and are sustained in response to global [nonlocal] properties of the system; Darvdov described solitons for the filamentous web.) Nonlocal electrons are trapped by the local charge on the protein filaments and hydrogen bonds; these nonlocal electrons interpenetrate in the filamentous web. Rather than having a simple transfer of input to output when the sum of the postsynaptic potentials reaches threshold, the input, interacting with the ultramicroscopic filamentous web, has nonlocal effects and is assimilated to the whole.

But this is not the end of it, according to Jibu and Yasue. Closely aligned with the filamentous web are water molecules. Each molecule, composed of two hydrogen and one oxygen atom, is thought of as a kind of quantum mechanical top with spin (represented by Pauli spin matrices). Water molecules have slight electrical polarities (for geometric reasons) and fit together, forming a *water megamolecule* over 50 micron regions. Such a water megamolecule requires a quantum physical description, which means that nonlocality obtains. Its quanta of energy—which can be thought of as particle-like and moving within a Bose field—are called "corticons." It turns out, Jibu and Yasue show, that the Bose field is electromagnetic in nature and that corticons are photons. *Thus intermediary in the "transfer function," Jibu and Yasue find water megamolecules and light (which surely gladdens the hearts of us old hippies)*.

Note that the macroscopic perimembranous region is described classically, whereas the filamentous web and water megamolecule are described quantum physically. The "transfer function" thus goes from the classical local to the quantum nonlocal and back again, a profound transformation, as the perimembranous macroscopic system interacts with the ultramicroscopic filamentous web and surrounding water megamolecules that fill 50 micron brain segments.

It is no wonder, then, that neuronal output is not regular, as a good Hodgkin-Huxley neuron should behave. Neuronal output is not a simple function of input but of the interaction between the perimembranous ionic currents controlled by input and a quantum physical system. A random change

that opens a single ion channel has global effects on the filamentous web and water megamolecule, which may induce a neuronal spike. *Classical and quantum systems interact at the interface between the perimembranous system and the filamentous neuropil surrounded by water megamolecules.* (This is not exceptional: well-known classical-quantum interfaces include lasers and superconductivity.) The notion of a straightforward input-output transfer function, which is at the core of information processing theories, cannot be sustained.

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One property of the somewhat elusive "fractal" concept is self-similarity. Linear fractals remain self-similar at increasingly high levels of detail. This fractal can be demonstrated by taking the Mandelbrot set magnified 100 times the original detail, and a further 100 times, and another 100 times, *yet the complexity remains invariant. The fractal never simplifies to irreducible atomic constituents in some kind of composition.* It is a vertiginous abyss (which is integral to the stunning visual power of the Mandelbrot set). Down and down, and complexity remains, to the horror of Democritus' tradition.

Our world is in some unclear sense deeply fractal; fractals have an affinity for natural forms, e.g., canyons, mountains, breaking waves, and trees. Fractals are used in computer graphics to simulate worlds. The related concept of "chaos" (deterministic chaos) is somewhat easier to grasp. Chaos is a common phase of nonlinear dynamical systems. *In wave terms, chaos is turbulence*. In chaos, the system moves about a spread-out attractor that has a characteristic form. Although the evolution of the system is predictable in the short run, over longer periods it cannot be predicted. This inability to predict is due to inevitable uncertainties about the initial conditions because of measurement error, an uncertainty that increases exponentially in time for chaotic systems, so that you can have no knowledge of where the system will end up. The system is on the chaotic attractor, to be sure, but after some time has passed, exactly where is unpredictable.

Here is the connection of chaos to fractals: chaotic attractors remain self-similar at increasing magnifications. That's curious: the chaotic attractor is fractal. Mandelbrot called them "strange attractors." There's a strange attractor that looks, say, like a big butterfly; that is, it shares an invariance with butterflies. This butterfly attractor is self-similar at increasing magnifications. (But Mandelbrot says (p. 194) that for nonlinear systems, strange attractors are not necessarily self-similar.) Sensitive dependence on initial conditions seems to be the hallmark of strange attractors for nonlinear dynamical systems.

David Alexander emphasizes that *the recursively organized brain systems are edge-of-chaos systems*, prone to bifurcate to new organizations. Each system within a system within a system...—Alexander offers the image of the Russian Matrioshka doll—is at the edge of chaos and moves freely either into chaos (turbulent flow) or explicate order (laminar flow). The various levels of the recursive organization interact, sending cascades of chaos and order back and forth, and each level at the edge of chaos moves between laminar and turbulent flow. Not only is there a horizontal part/whole interaction at each level, but there is a vertical less complex/more complex interaction as well between recursively embedded systems.

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Panta rhei! exclaimed Heraclitus. Everything flows. Everything flows spontaneously. The primitive upsurge of life forms, the *Ursprung*, the eruption of laminar and turbulent flow in edge-of-chaos neural systems... Living things flow spontaneously, and in that flow form and maintain their own boundaries: the *autopoiesis* of Maturana and Varela. The flow is self-sustaining, *autorhoetic*, by means of recurrent input that retunes the system so that it flows toward and settles into a symmetry-optimized state, until the retuning shifts and the flow starts up again like wind devils in the night chaparral [like Don Juan's "Allies"]. There is "vertical" flow between different levels of recursive organization—"cascades" of chaos and order, in Alexander's formulation—as well as the "horizontal" flow at a level. The indivisible explicate part/nonlocal whole architecture occurs both horizontally and vertically.

The integrated horizontal and vertical flow of the system is naturally mathematically represented by a wave function, and its evolution by a wave equation. Because of the nonlocality, the wave equation takes the form of the Schrödinger equation in quantum physics (*pace* Yasue). The indivisible interaction between explicate part and nonlocal whole takes place both at the level of the supersystem, where the parts are themselves complicated, recursively organized modules, and at the lowest level. In the latter, the explicate part is the classical neuronal apparatus with its fluctuating membrane polarization and transmembrane potential, with its propagating spikes, with its input and output orders. Interacting with this explicate neuronal apparatus is an ultramicroscopic sheaf, a filamentous proteinous web surrounded by water megamolecules, filling both intraneuronal and extraneuronal spaces. This web acts as a quantum system and manifests nonlocality, according to Jibu and Yasue (in press). (See also Hameroff.)

Recursively organized brain systems flow spontaneously, autopoietically, autorhoetically, bifurcating under edge-of-chaos conditions, tending to conserve invariants and optimize symmetry. The broken complexity

of our existence flows: we are such flowing, bifurcating systems whose operations entail nonlocality. Discourse expresses nonlocality also. Discourse flows and bifurcates in the form of explicate expressions of undivided wholes, flows and bifurcates when appropriated, flows and bifurcates and cascades without beginning or end or center or foundation or privileged interpretation or predictability:

NOTES

Preface N

1. This process of enfolding something to itself is called the "baker's transformation" in mathematics. The baker stretches the dough and then presses the dough back into itself; in mathematics, the "dough" is a purely topological, abstract mathematical construction. The baker's transformation requires an abstract space with peculiar properties, called "fractal." Fractal space remains self-similar at higher and higher levels of magnification; that is, it never simplifies to basic components. The chaotic roamings of complex systems take place in fractal space. In using a kind of baker's transformation in writing, by folding the text into itself, I have produced a fractal text.
2. "Nonlinear dynamics" will be much discussed in what follows. Briefly, for systems that are nonlinear, output does not change proportionally to input. Small changes in input to the system may lead to drastic changes in output from the system. Dynamical systems are systems whose states change over time. The evolution of dynamical systems is typically described by differential equations. Closed thermodynamical systems are classical examples; such dynamical systems come under the second law of thermodynamics according to which the entropy (disorder) of the system inexorably increases over time. Nonclassical systems are open to the environment and under certain conditions may decrease their entropy, i.e., increase the complexity of their order. Nonclassical systems taken together with their surround are, of course, subject to the second law of thermodynamics.
3. See Sabelli and Carlson-Sabelli (1989) on Heraclitus and dynamics.
4. I emphasize that throughout the book I appropriate the term "postmodern" to the versions of Heidegger and Derrida. Postmodernists in general comprise a somewhat wild and motley crew that is too diverse to represent here.
5. The active expressions of this paragraph—"I take," "I attempt"—are traditional modes of expression that hide what really went on: like the poet inspired by the muse, I was written. This creates a certain dilemma for the writing. The active mode is easier to read, especially for those for whom English is a second language, but "I take" expresses the very duality that postmodernism wants to surpass. The more difficult passive mode is consonant with being written. The text moves freely between active and passive modes, depending on context.
6. Of course, that which postmodernism calls "metaphysics" in turn calls something else by that bad name. In transpersonal psychology "metaphysics" means something good, something spiritual, beyond physics. I always mean "metaphysics" in the pejorative postmodern sense in this text.
7. "Deconstruction" is a postmodern critical technique that will be illustrated in the text that follows. For now we can say that it is a method for undermining the all-pervasive hegemony of metaphysics and disclosing what has been hidden.
8. Griffin 1988.
9. To anticipate chapter nine, the well-known physical principle of "least action" governs the evolution of nonlinear dynamical systems (Feynman, 1963, v.2, chapter 19). These systems change in a way that minimizes a certain energy, called the action. For complex

systems, as we shall see, action implies asymmetry. So least action finds symmetry. Least action also governs the evolution of discourse, where there is a symmetry between different groups of concepts in that the relations between concepts within the different groups tend to be invariant across sets. The continuing holistic movement toward a never-attainable truth maximizes symmetry across regions of discourse space. Thus to find truth, seek global symmetry.

10. Charles Scott made a very helpful and insightful comment midway in the writing: my project of translating Derrida's différance into neural network terms could not be launched without first deconstructing the brain.
11. Peat 1987; Bohm and Peat 1987; Briggs and Peat 1989.
12. Varela 1984; Maturana and Varela 1987; Varela, Thompson and Rosch 1991.
13. Varela 1979; Maturana and Varela 1980.
14. Prigogine 1980; Prigogine and Stengers 1984.
15. Yasue 1988; Jibu and Yasue 1993, in press; Yasue, Jibu, Misawa and Zambrini 1988; Yasue, Jibu and Pribram 1991.
16. Pribram 1971, 1991.
17. Globus 1989b (chapter one), 1991 (chapter two), 1990 and 1992a (chapter three), 1992b (chapter four), 1994a (chapter five), 1994b (chapter seven). I thank the publishers for permission to print revisions of the original articles.

Chapter One: The Self-Organizing Dream

1. Derrida 1988.
2. Saussure 1966.
3. Castaneda 1972.
4. For the expurgated version, see Globus (1989b). On the dream as self-organizing, see also Antrobus (1991) and Globus (1989a, 1993). In Mamelak and Hobson (1989), the self-organizing concept never enters in, although Kahn and Hobson (1993) claim that it foreshadows their paper which is entitled "Self-Organization Theory of Dreaming." Curiously, their paper is actually about radical thematic discontinuities in dreams as bifurcations at Prigoginian far-from-equilibrium conditions, not about self-organization; their paper seems to be mistitled.
5. Respectively, Globus 1986, 1990, 1992a, 1989c.
6. Fodor 1980; Pylyshyn 1980, 1984.
7. This idea owes much to David Bohm (1980); for some differences, see Globus (1987b).
8. See Maturana and Varela (1987) for the concept of input as perturbing rather than informing.
9. Hobson and McCarley 1977.

Chapter Two: The Chinese Room

1. Heidegger 1959, 1982.
2. Heidegger 1977.
3. Derrida 1982.
4. Derrida 1988.
5. Searle 1992, p. 92.
6. Cf. Pylyshyn 1984.
7. Rorty 1979.
8. Gibson 1966.

9. Ryle 1949.
10. Globus 1987a.
11. This point is generally overlooked in the criticism of Gibson's extreme anti-cognitivism (Ullman 1980).
12. Gibson 1979, p. 165.
13. Neisser 1976.
14. Marcel 1983a, b.
15. Yates 1985.
16. Husserl 1913/1960.
17. Searle 1983.
18. Fodor 1987.
19. Dennett 1991.
20. Neisser 1976, p. 9.
21. Fodor 1980.
22. Hubel and Wiesel 1979.
23. It should not be thought that only Searle and the Churchlands defer the problem of the semantic relation to empirical science. This deferral is a move widely adopted; the expectation that science will save metaphysics is typical of metaphysics. Natsoulas (1984 p. 244), for example, says that Gibson's abstract informational invariants which are picked up by the brain are "resonated to qualitatively" and this gives the stimulus information a "qualitative guise" so that "the perceiver becomes aware of external properties and events." But Natsoulas never explains how brain "resonance" relates information pickup qua abstract syntax to a perceptible world outside the brain, other than saying that "the environment would not look to the perceiver in any way unless there was produced in the visual system a special process" (Natsoulas 1989, p. 49, italics added). This "special process" proceeds "at a particular level" of the visual system (p. 49). But this "special process" occurring at a particular level of the visual system turns out to be brain resonance.

> The stream of visual perceptual experience (or awareness) of things is a temporally continuous brain process...that is a special kind of "resonating" to stimulus information, a kind that does not occur elsewhere in the visual system. (Natsoulas 1989, p. 49, italics added)

So the entire weight of the semantic relation is carried by the designation "special" applied to a particular level of the brain. What makes brain resonance at some level "special" so that the inside can get outside? It is left to future empirical science to explain this core problem of the metaphysical tradition.
24. Churchland and Churchland 1990, p. 36.
25. Dreyfus 1979, p. 190.
26. See Clark (1989, 1993) for discussions of why neural nets do not logically process symbols.
27. Churchland 1986.
28. Fodor 1980.
29. I do not use the term "monadic" in a strict Leibnizean sense. For me, the term implies a "windowless" entity for which there are no representations of the monad's surround but a plenum of possibilia within. For a book-length elucidation of the claim that we are monadic systems, see my *Dream Life, Wake Life* (Globus 1987a).
In a similar vein, Maturana and Varela (1980) have considered the brain to be a nonrepresentational closed system, dynamically coupled to the environment but not

dealing in information of the environment; it is only the observer that finds neural events representational (informational).

> ...change in structure of the nervous system constitutes a change in the domain of its possible states under conditions in which the representation of the causing circumstances does not enter as a component. (Maturana and Varela 1980 p. 132)

Put in connectionist terms, the neural networks have a trajectory of actual states in a state space of possible states, none of which represent input.

> The notions of acquisition of representations of the environment or of acquisition of information about the environment in relation to learning do not represent any aspect of the operation of the nervous system. The same applies to notions such as memory and recall... (Maturana and Varela 1980, p. 133)

So Maturana and Varela's account is not informational. Their nervous system's state space is a plenum of possibilia and sans representations, it is "windowless." Accordingly, their conception is "monadic" in my sense.

30. Searle does not seem to acknowledge his striking similarity to Heidegger, especially given Dreyfus' (1979, 1991) interpretation of Heidegger, which is puzzling, since Dreyfus is Searle's colleague at Berkeley.

Chapter Three: Continental Tradition and Cognitive Science

1. Farias 1987; Ferry and Renaut 1988.
2. Globus 1973, 1989c.
3. Chomsky 1980; Fodor 1980; Pylyshyn 1980, 1984.
4. Rumelhart, Smolensky, McClelland and Hinton 1986.
5. Olafson 1987, p.166.
6. Heidegger 1972, p.14.
7. Heidegger 1972, p.16.
8. Heidegger 1982, p.155.
9. Heidegger 1972, p.2.
10. See also Varela, Thompson and Rosch (1991) who build a bridge between Merleau-Ponty and connectionism, and Buddhist psychology as well.
11. For exceptions, see Cilliers (1990), Globus (1986, 1988, 1990, 1992a), Varela, Thompson and Rosch (1991), and Winograd and Flores (1986).
12. Heidegger 1972, p.27.
13. Dreyfus 1979, 1992; Dreyfus and Dreyfus 1986.
14. For helpful book-length discussions of Derrida, see Gasche (1986), Harvey (1986) and Norris (1987).
15. Schwab 1989.
16. Derrida 1982c, 1989.
17. Derrida 1974, 1978.
18. Erdelyi 1985; Klein 1976; Peterfreund 1971.
19. But see Rössler (1983) for a description of computers in terms of a subclass of differential equations.

20. Derrida 1982a, p. 6.
21. Derrida 1982a, p. 6.
22. Derrida 1982a, p. 12.
23. Derrida 1982a, p. 284.
24. Derrida 1982a, p. 7.
25. Derrida 1982a, p. 7, bracket added.
26. Derrida 1982a, p. 8.
27. I have discussed the wider sheaf of différance elsewhere (Globus 1992a).
28. Castaneda 1972.
29. Derrida 1978, p. 200.
30. Hopfield and Tank 1986.

Chapter Four: Noncomputational Cognitive Science

1. Chomsky 1980; Fodor 1980; Pylyshyn 1980.
2. But see the defense of the tradition by Clapin (1991).
3. For example, Adamopoulos and Anninos 1989; Bush and Sejnowski 1991; Carpenter and Grossberg 1990; Destexhe, Mainen and Sejnowski 1994; Hasselmo 1993; Horn and Usher 1990; Mel 1992.
4. Strong and Kaczmarek 1987.
5. Strong and Kaczmarek 1987.
6. Zucker 1987; Shepherd 1990.
7. Aston-Jones and Bloom 1981a, 1981b; Woodward et al 1979; Sessler, Cheng, Waterhouse 1988; Servan-Schreiber, Printz and Cohen 1990.
8. Douglas and Martin 1990.
9. Kaczmarek and Levitan 1987a; Westerfield, Joyner and Moore 1978.
10. Luscher and Shiner 1990.
11. See Prigogine and Stengers [1984] on the tendency for nonlinear dynamical systems at far from equilibrium conditions to shift unpredictably into states of increased complexity.
12. Black 1991; Crick 1989; Getting 1989; Shepherd 1990.
13. Schuster 1989.
14. Gallez and Babloyantz 1991.
15. For a model of fractally configured neural networks, see Merrill and Port (1991).
16. See also Rapp et al 1987.
17. Babloyantz 1986; Babloyantz and Destexhe 1986; Babloyantz, Salazar and Nicolis 1985; Gallez and Babloyantz 1991; Mayer-Kress and Layne 1987; Nicolis 1985; Skarda and Freeman 1987; Xu and Xu 1988.
18. See also Freeman 1987; Nicolis 1986; Nicolis and Tsuda 1985; Skarda and Freeman 1987.
19. Babloyantz, Salazar and Nicolis 1985; Gallez and Babloyantz 1991.

Chapter Five: Nonlinear Dynamical Psychiatry

1. Erdelyi 1985; Peterfreund 1971.
2. Skarda and Freeman 1990 p. 275.
3. Abraham 1990 p. I-1.
4. Mandell 1982 p. 62.
5. Freeman 1992 p. 1079-1080. See also Mandell and Selz 1992.

6. Cohen and Servan-Schreiber 1992a, 1992b, 1993; Hoffman 1987, 1992; Hoffman and Dobscha 1989; Hoffman and McGlashan 1993; Krieckhaus, Donahoe and Morgan 1992; Schmid 1991; Vinogradov, King and Huberman 1992.
7. Hestenes 1992; Hoffman 1987, 1992; Sabelli, Carlson-Sabelli and Javaid 1990.
8. Callahan and Sashin 1987.
9. Li and Spiegel 1992.
10. King, Barchas and Huberman 1983.
11. Mandell 1983b.
12. Pylyshn 1980, 1984.
13. For an excellent tutorial review of the mathematical concepts involved, see Pritchard and Duke 1992b. See also the discussion of Elbert et al (1994) on deterministic chaos in excitable cell assemblies which reviews the basic concepts of chaos. Barton (1994) has reviewed the concepts and applications of chaos and self-organization in psychology.
14. See also Germine 1993.
15. Shaw 1981; West 1990.
16. Basar 1990a.
17. Gallez and Babloyantz 1988; Lutzenberger et al 1992.
18. Canavier, Clark and Byrne 1990.
19. See Baars (1988) for a discussion of recursion in the organization of consciousness, but in a traditional computational framework.
20. Kaczmarek and Levitan 1987a; Westerfield, Joyner and Moore 1987.
21. Nicolis and Prigogine 1989; Prigogine and Stengers 1988; Sabelli and Carlson-Sabelli 1989.
22. The information processing explanation has always been suspect in that when computer hardware is faulty, the computer simply doesn't work. Furthermore, the notion of program modification by learning makes sense but it is quite unclear how chemicals might change computational rules. The hypothesis that the neurochemistry changes the brain's attunement, however, can be easily conceived.
23. There is no attractive force at work here. As we shall see in chapter eight, a certain energy—the neural action—is minimized and attractors are states of least action.
24. There is a tendency for bipolars to have shorter intervals between manic and depressive episodes as the disease progresses, until an end stage of "rapid cycling" is reached. The assumption here is that the separatrice between manic and depressive attractors is lowered as the disease progresses.
25. Davis, Kahn, Ko and Davidson 1991.
26. Andreason and Olson, 1982.
27. Davis, Kahn, Ko and Davidson 1991.
28. Hoffman 1987, 1992; Hoffman and Dobscha 1989; Hoffman and McGlashan 1993.
29. Hoffman 1987, p.180, bracket added.
30. Hoffman and McGlashan 1993 p.125.
31. ibid, p. 126.
32. West 1990.
33. Koukkou et.al. 1993.
34. Elbert et.al. 1992.
35. Adamopoulos and Anninos 1989; Carpenter and Grossberg 1990; Destexhe, Mainen and Sejnowski 1994; Hasselmo 1993; Mel 1992.
36. Basar 1990b.
37. Canavier, Clark and Byrne 1990; Rapp, Zimmerman et al 1985.
38. Softky and Koch 1992.
39. Shaw 1981.
40. See the defense of modeling by Cohen and Servan-Schreiber (1992c).

41. Basar 1990b, p. 24.
42. For these methods, see Pritchard and Duke, 1992a, 1992b.
43. Elbert, Lutzenberger, et al, 1992.
44. Basar 1990a, 1990b; Gallez and Babloyantz 1991; Mayer-Kress and Layne 1987; West 1990; Zak 1991.
45. West, 1990, p. 255.

Chapter Six: Eruption of Other and Self

1. For a discussion of Lacan's usage of autre, see Grange 1989.
2. DSM-III-R is the official diagnostic and statistical manual used by clinicians for coding psychiatric disorders.
3. Ekstasis is a Heideggerian idea (Heidegger 1982) which I am appropriating. (Here the English "ecstasy" helps with the sense of ekstasis.) To be ekstatic is to be outside oneself, erupting into the life-world. (For an exaggerated form of ekstasis, think of the manic attack.)
4. Klein 1967; Peterfreund 1971; Rosenblatt and Thickstun 1970; Rubinstein 1967; Schafer 1976.
5. Prigogine and Stengers 1984; West 1990; Skarda and Freeman 1987, 1990.
6. There was something about the rattling sound that penetrated me at a preverbal level, whereas my defenses were effective against the funeral sounds.
7. Under the principle of least action, dynamical systems maximize polaron balance (chapter eight).
8. See the seminal development of the autopoiesis concept by Maturana and Varela (1980, 1987) and Varela (1979).

Chapter Seven: Postmodernism and the Dream

1. Bennington and Derrida 1992.
2. E.g. Feigl 1967; Ryle 1949; Savage 1976.
3. For a penetrating discussion of the dreaming subject from a postmodern and Jungian standpoint, see Kugler (1993).
4. Feynman, Leighton and Sands 1964.
5. As discussed in chapter three, in Heidegger's terms, the derivative dualism is "time" and "being." The fundamental dynamic, which Heidegger refers to by es (it), brings forth being and time. *Es gibt Sein. Es gibt Zeit.* (Heidegger 1969).
6. I do not mean to imply that Heidegger and Derrida hold to this conclusion; their realism is not monadological.

Chapter Eight: The Excision From Discourse

1. Hodgkin and Huxley 1952.
2. Hille 1992.
3. Edelman 1989, p. 68.
4. van Essen, Anderson and Felleman 1992.
5. Selemon and Goldman-Rakic 1985, 1988.
6. Goldman-Rakic 1988, p. 152.
7. Goldman-Rakic 1988, p. 150.

8. Yasue et al 1988; Yasue, Jibu and Pribram 1991; Jibu and Yasue 1993 and in press.
9. Feynman 1964.
10. Yasue and J.-C. Zambrini 1982; Yasue and Misawa 1987.
11. Sejnowski and Rosenberg 1986.
12. A great deal of the above discussion rests on the notion of "symmetry," which needs some unpacking. I am talking about the global symmetry of polar opposites that achieve a dynamical balance or harmony, like Yin and Yang in the Tao. (Neils Bohr included the Tao symbol in his coat-of-arms.) I shall call this dyad the polaron, and think of the brain, with its excitatory, inhibitory and modulatory interactions, as a nonlinear dynamical system whose modularity consists in both parallel (autonomous) and interactive (participatory) polarons.

    The complexity of the polaron varies; it might be only two neurons or the canonical cortical circuit described by Douglas and Martin (1990), which is complexly triangular. (This canonical circuit contains two populations of pyramidal neurons, one superficial and one deep, and a third population of inhibitory GABAergic neurons, all of which connect to one another, but with varying strength of connectivity.) Whatever the neural architecture, the tendency is toward dynamical balance of polarizing influences which minimize the neural action (minimize the LaGrangean operator in the neural wave equation).
13. I thank Milea Froes for dialogue on language.

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In the series ADVANCES IN CONSCIOUSNESS RESEARCH (AiCR) the following titles have been published thus far or are scheduled to appear in the course of 1995:

1. GLOBUS, Gordon D.: *The Postmodern Brain*. 1995.
2. ELLIS, Ralph D.: *Questioning Consciousness. The interplay of imagery, cognition, and emotion in the human brain*. 1995.
3. JIBU, Mari and Kunio YASUE: *A Quantum Theory of Consciousness*. n.y.p.

5452

This interdisciplinary work discloses an unexpected coherence between recent concepts in brain science and postmodern thought. A nonlinear dynamical model of brain functioning is developed, in which the evolution of brain states is viewed as an autopoietic, autorhoetic, self-organizing, self-tuning eruption under multiple constraints and guided by an overarching optimization principle which insures conservation of invariances and enhancement of symmetries. The nonlinear dynamical brain as developed shows quantum nonlocality, undergoes chaotic regimes, and does not compute. Heidegger and Derrida are "appropriated" as dynamical theorists who are concerned respectively with the movement of time and being (*Ereignis*) and text (*Différance*). The chasm between postmodern thought and the thoroughly metaphysical theory that the brain computes is breached, once the nonlinear dynamical framework is adopted. The book is written in a postmodern style, making playful, opportunistic use of marginalia and dreams, and presenting a nonserial surface of broken complexity.

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