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Mode Transition and Change in Variable Use in Perceptual Learning

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Runeson, Juslin, and Olsson (2000) proposed (a) that perceptual learning entails a transition from an inferential to a direct-perceptual mode of apprehension, and (b) that relative confidence—the difference between estimated and actual performance—indicates whether apprehension is inferential or direct. In 3 experiments participants received feedback on judgments of force; the results replicated Runeson et al.'s observed decrease in overconfidence but showed more overconfidence. Relative confidence depended on how performance was defined. An attempt to manipulate confidence failed, but trait confidence affected relative confidence. It was concluded that overconfidence does not necessarily signal inferential functioning and that a decrease in overconfidence might occur in a direct-perceptual mode. A theory of learning within the direct-perceptual mode, in addition to learning through a mode transition, appears necessary.

The ecological approach in psychology has characterized perceptual learning in terms of differentiation (Gibson & Gibson, 1955) and the education of attention to

information—variables detectable in energy fluxes that specify properties of the perceiver's environment (Gibson, 1966). One elaboration of that theory (Jacobs & Michaels, 2002, 2006) proposes that learning is itself an informationally guided process of traversing an information manifold to a locus that permits the meeting of task demands. The approach assumes that all the while, perception is direct; that is, unmediated and noninferential. A different form of perceptual learning, the mode transition, has been proposed by Runeson, Juslin, and Olsson (2000). These authors argued, "Competence entails the use of advanced kinematic information in a direct-perceptual ('sensory') mode of apprehension, in contrast to beginners' use of simpler cues in an inferential ('cognitive') mode of apprehension" (p. 525). In other words, performance is said to improve because perceivers graduate from an inferential to a direct-perceptual mode of apprehension. In this article, we investigate the mode transition hypothesis and the measures that evidence its occurrence.

Historically, inferential perception and direct perception have been considered to be alternative theoretical positions. Indirect perceptionists have asserted that perception is inferential; ecological perceptionists have asserted that perception is direct. A first difference between inferential and direct perception is that inferential perception is associated with the use of simple variables that are ambiguous with respect to properties to be perceived. The assumption of stimulus ambiguity lays a basis for the claim that properties of interest are inferred from these so-called elementary properties. Adherents of direct perception, on the other hand, expect observers to use analytically complex variables that specify to-be-perceived properties, where specification obviates the need for inference. Runeson et al. (2000) took as one line of evidence in favor of the mode transition hypothesis that, before practice, judgments of novices are often based on variables that correlate only marginally with the to-be-perceived kinetic property but that, after a minimal amount of practice, judgments come to be based on more advanced information. Analogous findings have been reported in a number of other studies (Jacobs, Michaels, & Runeson, 2000; Jacobs, Runeson, & Michaels, 2001; Michaels & de Vries, 1998).

A second line of support for the mode transition hypothesis is provided by the degree of confidence expressed by observers (Runeson et al., 2000). Differences in confidence judgments have historically been shown to be based on whether a task is sensory or cognitive. A typical sensory task, for instance, would be to judge which of two line segments is the longer, and a typical cognitive task would be to estimate whether France or Nigeria has the larger population. Sensory tasks appear to be characterized by underconfidence—perceivers report that they are performing more poorly than they are, in fact, performing (Juslin & Olsson, 1997). Relative confidence is defined as the difference between the percentage of judgments that are actually correct and the percentage of judgments estimated to be correct by the perceiver. In contrast, cognitive tasks appear to be characterized by overconfidence or well calibrated confidence (e.g., Juslin & Olsson, 1997; see also Baranski & Petrusic, 1999, for a contrary view). Runeson et al. reasoned that confidence judg-

ments might, therefore, be a useful index of whether observers perform a task in a direct-perceptual ("sensory") mode or an inferential ("cognitive") mode. In their colliding-balls experiment, Runeson et al. reported that confidence judgments of novices tended to be well calibrated, whereas when the novices became experts, they tended to be underconfident. This supports the mode transition theory because it seems to indicate that performance became less often inferential and more often direct perceptual.

The need for an ecological learning theory has been emphasized (e.g., Michaels & Beek, 1995), and the mode transition hypothesis might be a major breakthrough in that respect. Furthermore, the issue of mode transition is central to debates on direct versus inferential processing (or direct perception versus heuristics; e.g., Gilden & Proffitt, 1989, 1994; Runeson, 1995; Runeson & Vedeler, 1993). As pointed out by Runeson et al. (2000), previous results might have contained a mixture of inferential and direct-perceptual performance, thereby complicating their interpretation. Additional empirical evidence on the nature of the two modes and the transition is therefore desirable (cf. Andersson, Kreegipuu, & Runeson, 2001; Kreegipuu & Runeson, 1999). This contribution aims to provide such further evidence. We exploited a variation on a paradigm used by Michaels and de Vries (1998); participants observed a stick figure executing a bimanual pull (see Figure 1 for a static image from the displays) and were asked to judge the relative pulling force.

The pull-perception task is suited for our purpose for three reasons. First, as is relative mass, relative force is a kinetic (or dynamic) property. Because the optic array comprises only kinematic variables (e.g., velocities and angles), kinematic variables must lay the basis for the perception of kinetic properties. Relative pulling force has been shown to be specified by kinematic patterns (Michaels & de Vries, 1998), which provides perceivers with the opportunity to detect such information

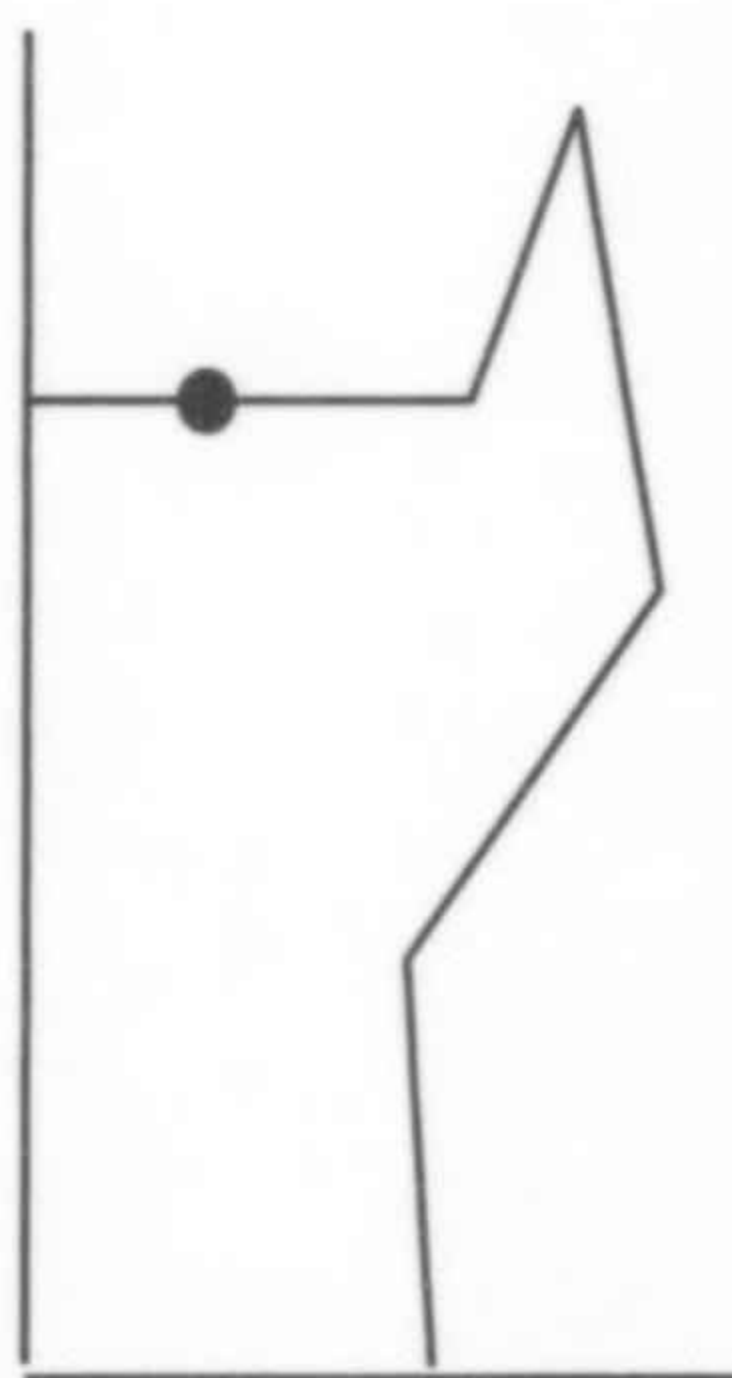


FIGURE 1 The starting and ending configuration of the stick figure puller used in all experiments. See Method sections for details.

and, thus, to apprehend relative pulling force in a direct-perceptual mode. Second, Michaels and de Vries showed that observers often begin with less useful variables but converge on more useful variables if given practice with feedback. Finally, dynamic pulling is easy to simulate; the center-of-mass motion of human pullers can be described well using a model with only a few degrees of freedom (Michaels & Lee, 1996; Michaels, Lee, & Pai, 1993). We used this model to generate center-of-mass motions of the stick figure pullers. Given various constraints (constant elbow and ankle positions), the center-of-mass positions are uniquely related to limb positions, and the center-of-mass motions can easily be transformed into stick figure motions.

Research has shown that both specifying and nonspecifying variables play a role in the perception of pulling force; the implicated nonspecifying variables are maximal displacement and maximal speed of the puller's center of mass (Michaels & de Vries, 1998). The particular variables that are exploited depend on the relative usefulness of variables, which can be measured as the correlations between relative pulling force and the nonspecifying variables. These correlations depend on the characteristics of the particular set of pulls, which depend, in turn, on which model parameters are manipulated to generate the set of pulls. For Experiment 4 of Michaels and de Vries and the experiments reported here, the correlation between a force-specifying invariant and maximal displacement was $-.05$, and the correlation between the force-specifying invariant and maximal speed was $.74$ (the intercorrelation of speed and displacement was $.62$). The rationale for choosing this particular set of stimuli was twofold. First, keeping the correlations among the kinematic variables as low as possible would, we hoped, not inadvertently result in good feedback when the observer is using a nonspecifying variable. Second and relatedly, this set has been shown to encourage perceivers to converge on higher-order specifying variables (cf. Experiments 3 and 4 of Michaels & de Vries, 1998). We expected that this set of displays would be suited to our purpose, and we therefore used it in all experiments and in all phases of the experiments (i.e., pretest, practice, and posttest).¹

EXPERIMENT 1

As described previously, Runeson et al. (2000) demonstrated changes in variable use and a decrease in relative confidence in a paradigm in which perceivers estimated the relative mass of colliding balls. Convergence on more useful variables was also evident in the perception of pulling force (Michaels & de Vries, 1998). Here we attempt to replicate the decrease in confidence in the latter paradigm. Runeson et al. asked observers to make binary judgments; more precisely, they asked observers to indicate which of two colliding balls was the heavier. We also

¹Experiments 1 and 2 are, in fact, replications of experiments presented in Jacobs (2001, chap. 4); he found little learning in a less constrained set of displays.

asked participants to make binary judgments, first to make the experiment similar to Runeson et al.'s experiment, and second because binary judgments are more appropriate than quantitative judgments if one also solicits confidence judgments. We therefore used the classic psychophysical method of constant stimuli, in which participants are asked to categorize each display with reference to a standard. The standard was not explicitly presented; participants were to judge whether the force on a particular pull was above or below the average of all forces in the collection of displays. This is a commonly used technique in visual psychophysics (e.g., McKee, 1981; Regan & Hamstra, 1993; Regan & Vincent, 1995).

Method

Participants. Eight undergraduate students at the University of Connecticut participated. They received credit in partial fulfillment of their introductory psychology course's experimental requirement.

Displays and design. The center-of-mass motions of the stick figure display were based on the three dynamic parameters of the model of center-of-mass motions in bimanual pulling of Michaels and Lee (1996): slack, stiffness, and torque. The model consists of a mass, m , on an inverted pendulum, as depicted in Figure 2. The pendulum is attached to a vertical support by an initially slack elastic cord (Figure 2, Panel A). A constant torque and, after initiation, also a torque caused by gravity accelerate the mass away from its initial upright position until the cord is stretched (Figure 2, Panel B). The stiffness of the cord then decelerates the pendulum until it reaches the position of maximal displacement (Figure 2, Panel C), where the stiffness reverses the motion of the pendulum, eventually leading it back to its initial position. Thus, the motion of a pendulum of a particular mass and length is determined by three model parameters: a constant torque, the initial slack of the cord, and the stiffness of the cord.

We created 36 simulations—of bimanual pulls on a horizontal bar at elbow height—by manipulating two of the model's three parameters. Stiffness and torque

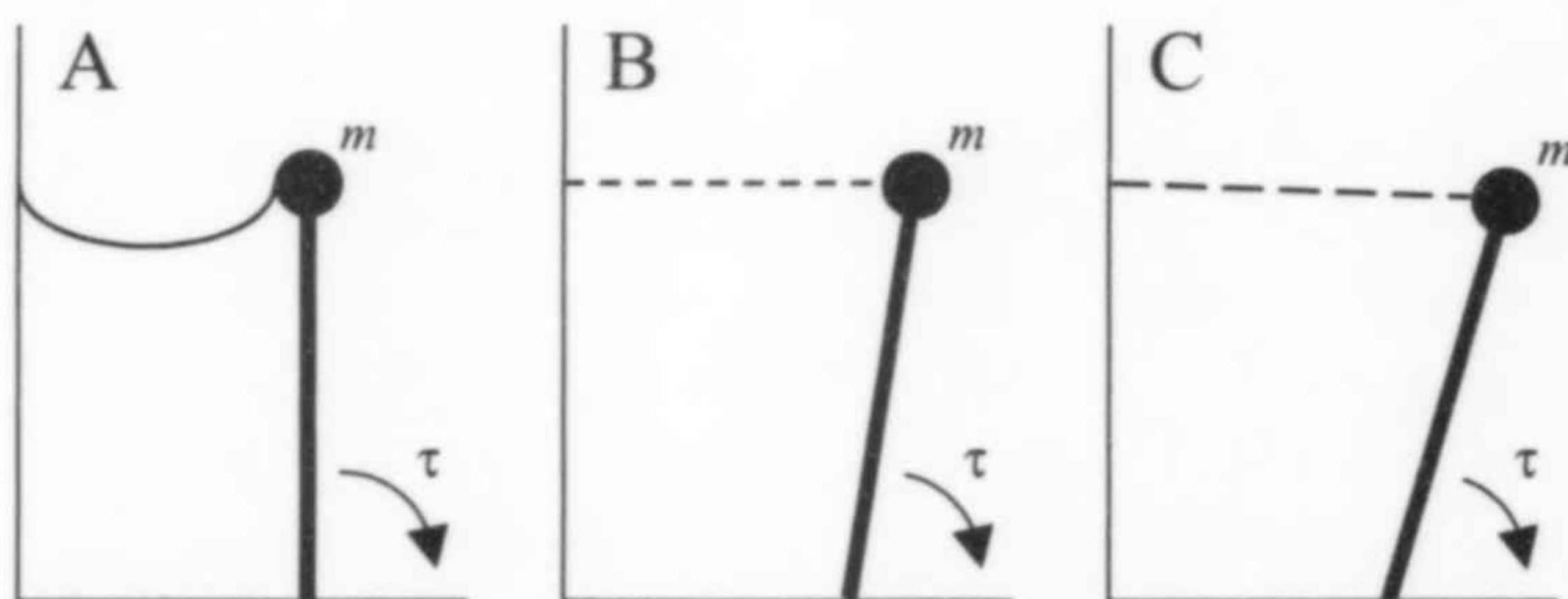


FIGURE 2 The inverted pendulum model for pulling presented by Michaels et al. (1993). See text for explanation.

had six levels each (6, 9, 12, 15, 18, 21 kN/m and moment arms of 2, 4, 6, 8, 10, 12 cm, respectively). Slack was constant at 7 cm. In all trials the length of the pendulum was 90 cm and the mass of the bob was 75 kg. The stick figures on the screen were 7 cm tall, about 25 times smaller than the pullers whose motion was simulated. The stick figures were presented as white lines on a black background, in a simulation window of about 10×10 cm (350×350 pixels), on a Macintosh CRT monitor at its refresh rate of 75 Hz. Using the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997) within a Matlab program, we made sure that the animations of the stick figures were tightly synchronized with the buildup of the computer screen. Participants viewed the animations from a distance of approximately 40 cm.

The experiment consisted of a 36-trial pretest, four 36-trial practice blocks, and a 36-trial posttest. Each block comprised the 36 displays in completely randomized order.

Procedure. Participants started a series of trials by placing the cursor and clicking on a *start* button with a computer mouse. After each display generated by a given set of simulation values was presented three times in rapid succession, a response window appeared on the screen. Using the mouse, participants entered two judgments: a binary judgment about whether the peak force exerted by the puller was *above* or *below* the average of all pulls, which was entered by clicking on one of two buttons; and a quantitative judgment, entered on a slider ranging from 50% to 100%: "Placing the slider at the 50% end means that your force judgment is a random choice ... placing the slider at the 100% end means that you are sure that your force judgment is correct." Participants were free to change their judgments until they clicked the *ready* button. In the pretest and posttest, the *ready* button initiated a new trial. On practice trials, clicking the *ready* button was followed by feedback: The message *correct* or *incorrect* appeared on the screen, depending on whether or not the participant had correctly judged that the pulling force was above or below average. Each session lasted about 1.5 to 2 hr.

Results and Discussion

On average, 61% of the force judgments were correct in the pretest and 81% of judgments were correct in the posttest. Participants were able to perform the task, and they improved after practice with feedback. A paired *t* test on the percentages of correct judgments in the pretest and posttest indicated that the improvement was significant, $t(7) = 3.03$, $p < .02$, one-tailed. The point biserial correlation between judgment and force increased from .199 on the pretest to .639 on the posttest, on average; a *t* test on these correlations² showed a significant improvement, $t(7) = 3.44$, $p < .01$, one-tailed.

²All significance tests on correlations in this and subsequent experiments were done on the correlations' *Z* transformations.

TABLE 1
Performance and Relative Confidence for Individuals in Experiment 1

Participant	% Correct		Relative Confidence	
	Pretest	Posttest	Pretest	Posttest
1	66.7	91.7	4.0	-2.1
2	66.7	91.7	3.7	-11.6
3	75.0	80.6	4.8	12.6
4	42.9	85.7	29.9	-1.6
5	69.4	80.6	11.5	4.1
6	33.3	78.8	48.5	-3.1
7	63.9	75.0	13.6	5.6
8	72.2	63.9	10.4	15.6
M	61.3	81.0	15.8	2.4
SD	14.9	9.1	15.7	8.9

As to the main question of whether relative confidence, the difference between average confidence and percentage correct, decreased with practice, we found that it did so systematically over blocks of trials, from 15.8% in the pretest to 2.4 % in the posttest. An analysis of variance (ANOVA) with Block (1 to 6) as a within-subjects factor showed that the decrease was significant, $F(5, 35) = 2.28$, $p = .035$, again one-tailed. In line with the mode transition hypothesis, we replicated a decrease in relative confidence.

Both the performance and relative confidence scores are presented by individual participants in Table 1. Six out of 8 participants exhibited a decrease in relative confidence. Half of the participants became underconfident in the posttest, whereas the rest remained overconfident. The standard deviation of relative confidence decreased from 15.7% in the pretest to 8.9% in the posttest, suggesting that over participants, confidence judgments became more consistent. The difference between pre- and posttest scores was 13.4% on average, with a large standard deviation of 19.7%. These results reflect large individual differences among participants.

To summarize, this experiment replicated the decrease in relative confidence reported by Runeson et al. (2000). We, however, found more overconfidence: With practice, our participants changed from overconfidence to near well calibrated confidence, whereas participants in the experiments of Runeson et al. changed from well calibrated confidence to underconfidence (more precisely, from 0% to -11% underconfidence). The next experiment addresses an explanation of the decrease in confidence that is invited by the higher level of confidence in our experiment.

EXPERIMENT 2

The fact that we observed overconfidence even in the posttest of Experiment 1, whereas Runeson et al. (2000) observed underconfidence, might have been due to

the more frequent use of an inferential mode by our observers which, in turn, might have been due to the use of nonspecifying variables in the case of our observers or to differences in simulation techniques and display qualities (Runeson & Andersson, 2004). More interesting, however, is that the larger overconfidence invites an alternative view of the origin of the decrease in overconfidence. Assume that confidence always reflects the accuracy with which the exploited variable is detected, whatever that variable may be. Imagine further two perceivers who express an equal absolute confidence in their detection of their exploited optical variables. Say that one participant uses a nonspecifying variable; this would affect performance, but not confidence. Such a perceiver would show overconfidence because performance is less accurate than the confidence. The second perceiver, who detects a specifying variable with the same degree of accuracy, would perform better relative to the experimenters' intended quantity. When that better performance is compared with the same confidence, there would be less overconfidence than shown by the first perceiver. Applying this logic to our Experiment 1, most overconfidence was found in the pretest—namely because novices are more likely to use nonspecifying variables. Under this interpretation, *overconfidence would be due to the fact that the performance measure is not a measure of what participants are actually doing.*

If, indeed, overconfidence is due to reliance on nonspecifying variables, rather than to a different kind of cognitive process, an apparent decrease of overconfidence, as observed in Experiment 1, might be due to convergence on specifying variables. This reasoning led to the expectation that overconfidence, as measured here, should increase if perceivers are induced to rely more on nonspecifying variables. To test this, we adopted the methods of Experiment 5 of Michaels and de Vries (1998), which showed that perceivers' reliance on nonspecifying variables could be attained through feedback contingent on such variables. In Experiment 2, we made feedback contingent on often-used nonspecifying variables. For a first group of participants, the displacement group, feedback "on accuracy" was contingent on the maximal displacement of the puller's center of mass. For a second group, the speed group, feedback was contingent on maximal speed. To the extent that categorical feedback is also effective in inducing reattunement (Michaels & de Vries, 1998, had used scalar feedback), we expected that these groups would show an increase in overconfidence. It is more likely that an effect would be observed with displacement because speed was highly correlated with relative pulling force ($r = .74$). Feedback contingent on speed, therefore, may be the same as feedback contingent on force in a large percentage of trials.

In summary, participants who receive feedback based on nonspecifying variables are hypothesized to show an increase in overconfidence. This is in contrast to participants in Experiment 1, who received feedback on force and exhibited a decrease in overconfidence.

Method

As in Experiment 1, participants were instructed to judge peak force and to give confidence estimates. The same pretest-practice-posttest design was used. Also as in Experiment 1, participants were instructed to judge relative pulling force. Feedback, however, was based on the maximal speed of the puller's center of mass for the speed group and on the maximal displacement of the center of mass for the displacement group. This means, for instance, that a response of *below average* was said to be correct if maximal speed or maximal displacement, respectively, was less than average. The speed group and the displacement group each had 8 participants. Perceivers in both groups were instructed to enter their answer and confidence judgment with respect to force. They were told that they would receive feedback on their performance in the training blocks, but the nature of the feedback was not revealed. In all other regards, the experiment was the same as Experiment 1.

Results and Discussion

We divide our results into three sections, each adopting a different definition of performance accuracy. In the first section we define performance as we had in Experiment 1, in terms of the accuracy of judging pulling force. In the second section, performance is defined relative to the feedback conditions that distinguished groups. In the third section we introduce the idea of an intrinsic performance measure. In all three sections, to facilitate comparisons with Experiment 1, those data are included as a third condition, in which force feedback was given.

Force-referential performance. Remember that our hypothesis consisted of two parts: Participants would converge on nonspecifying variables on which they received feedback, and, as a result, overconfidence would increase. We address these issues in turn.

If participants indeed converged on variables on which they received feedback, the force, speed and displacement groups should differ in which variable they exploited in the posttest—the force group (Experiment 1) relying more on a specifying variable, the speed group relying more on maximal speed, and the displacement group relying more on maximal displacement. The r^2 of the correlations relating judgments to each of the kinematic variables are presented by group and blocks of trials in Figure 3.

Inspection of Figure 3 shows again that in the force-feedback condition (i.e., Experiment 1) judgments came to correlate more highly with actual force (top panel) than did the judgments of members of the other groups. A Group (force feedback, speed feedback, and displacement feedback) $\times$ Block repeated measures ANOVA on the correlations between judgments and force showed that the difference between feedback groups on the judgment–force r s was significant, $F(2, 21)$

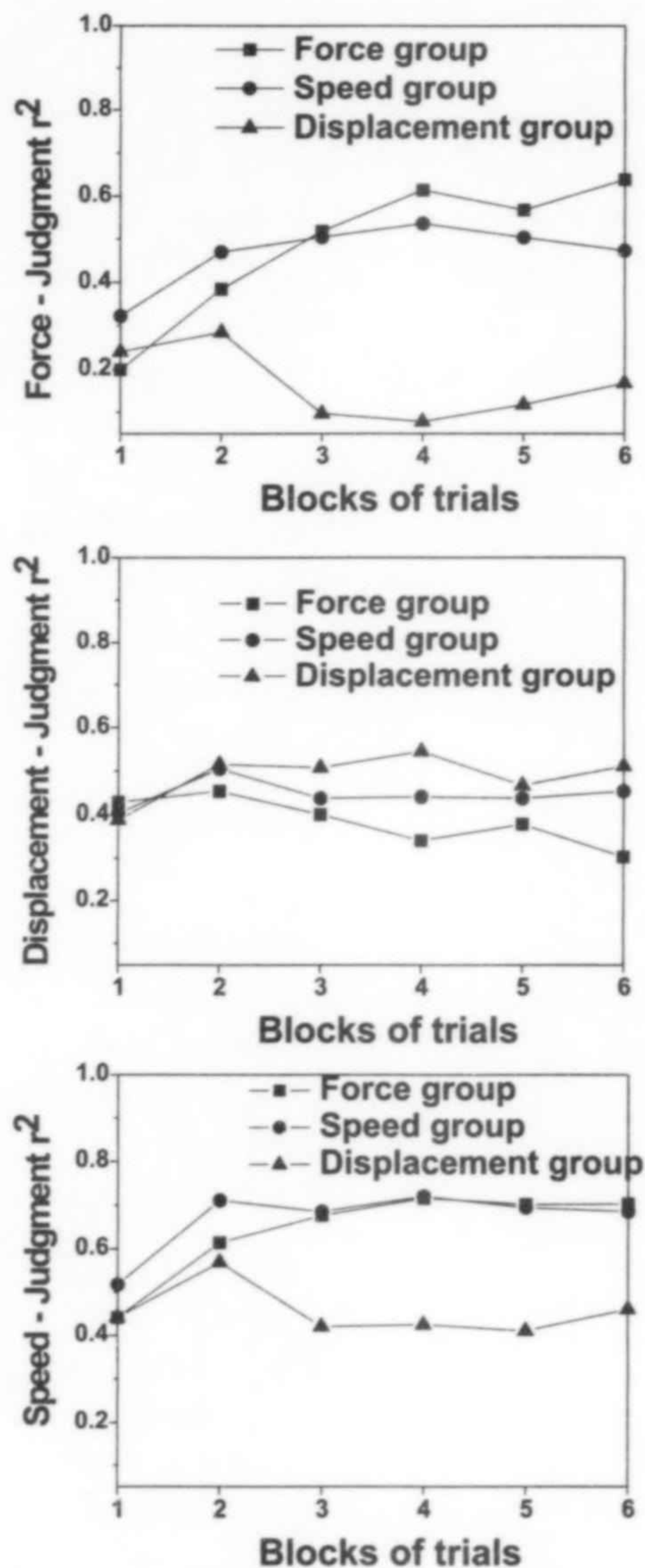


FIGURE 3 Average squares of correlations between candidate variable and binary judgments over blocks for the three feedback groups. In the top panel, the candidate variable is force; in the center, it is displacement; and in the bottom panel, it is speed.

$= 10.02, p < .001$, revealing the superiority of the force group. The middle panel hints that a possible increase in the correlation of judgment and displacement occurs only in the group given displacement feedback; however, an ANOVA on displacement-judgment correlations yielded no significant differences among groups. The bottom panel seems to show that both the speed and force groups showed increasing correlation with speed. An ANOVA on the judgment-speed correlation revealed higher correlations for the speed and force groups than for the displace-

ment group, $F(2, 21) = 7.4, p < .004$. That both force and speed groups show high speed-judgment correlations is not surprising given the high correlation between force and speed.

The way the results were plotted in Figure 3, although making the previously discussed characteristics clear, obscures other characteristics. Comparing the values for the force group in the top and bottom panels, for instance, reveals that the correlation between force and judgment was consistently smaller than the correlation between speed and judgment. This suggests that convergence on a specifying variable was perhaps thwarted by the high correlation between force and speed. Second, a comparison of all sets of correlations in the displacement group showed a slight systematic superiority of the displacement-judgment correlations over the velocity-judgment correlations and a huge superiority of the displacement-judgment correlations over the force-judgment correlations. But still the judgment-displacement r^2 s in this group were never higher than .6. Thus, it seems that the displacement feedback, although preventing participants from relying on force-specifying information, did not induce systematic reliance on displacement. Again, the benefit of feedback on displacement seemed to spill over onto speed, presumably due to the fairly high intercorrelation of displacement and speed.

In sum, the feedback contingent on the different nonspecifying variables appeared to foster reliance on the different nonspecifying variables, although the effects were neither as strong nor as reliable as those that had been reported when scalar, rather than categorical, feedback was offered (Michaels & de Vries, 1998, Experiment 5).

We now turn to the second part of our hypothesis, which predicted that a convergence on nonspecifying variables in the speed and displacement groups would result in an increase in overconfidence. The left half of Table 2 presents the percentages of trials in which participants correctly judged force in the pretest and posttest, along with their average relative confidence. A Group (force feedback, speed feedback, and displacement feedback) $\times$ Block (pretest, posttest) ANOVA on relative confidence revealed a significant Group $\times$ Block interaction, $F(2, 21) = 4.27, p = .028$; as expected, the force group showed a decrease in relative confidence, whereas the speed and displacement groups showed an apparent increase

TABLE 2
Average Performance and Relative Confidence by Groups in Experiment 2

Group	Force-Referential				Feedback-Referential			
	% Correct		Relative Confidence		% Correct		Relative Confidence	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Force	61.3	81.0	15.8	2.4	61.3	81.0	15.8	2.4
Speed	64.9	69.4	15.5	20.1	72.6	77.8	7.9	11.8
Displacement	60.8	60.2	15.5	25.5	66.1	69.5	10.3	16.1

from pretest to posttest. There was also a marginally significant main effect of group, $F(2, 21) = 3.35, p = .055$; the force condition tended to have lower relative confidence than did the speed and displacement groups.

In short, we found that Experiment 1's decrease in relative confidence was limited to the condition in which feedback was based on force. In conditions in which participants were encouraged to rely on other variables, they did so, and their relative confidence increased. This is in contrast to the results in the colliding-balls paradigm reported by Runeson and Andersson (2004): Although their r^2 values reflect the same kind of influence of feedback as in our study, namely, participants' judgments appear to correlate highly with the variable on which they received feedback, relative confidence decreased in all three feedback conditions. Contradictory empirical results from the pulling-force paradigm and the colliding-balls paradigm undermine the role of relative confidence as an indicator of mode of apprehension.

Feedback-referential performance. Previously, performance, and hence relative confidence, was defined relative to the explicit task demand of judging force. Whereas this is a straightforward choice when force feedback is given, the speed feedback and displacement feedback redefine the task demands. Although participants were instructed to report force, the feedback indicated that force was related to kinematic variables that, in fact, did not correlate highly with the simulated force. In this section, we reconsider performance by defining it with respect to the task demands created by the feedback. Under the new definition, percentage of correct judgments in the speed group is defined with respect to speed, and percentage of correct judgments in the displacement group is defined with respect to displacement. The results so defined are presented in the right half of Table 2.

Feedback-referential performance improved over blocks, as already implied by the changing correlations depicted in Figure 3: A Block (pretest, posttest) $\times$ Group (force feedback, speed feedback, and displacement feedback) ANOVA on percentage correct showed a significant effect of block, $F(1, 21) = 12.49, p = .002$; performance improved over blocks. The Block $\times$ Group interaction, $F(2, 21) = 3.73, p = .04$, showed that performance in the force group improved more than in the other groups. Clearly, speed and displacement feedback were not as effective as force feedback in drawing participants to rely on these variables. The modest improvement in the speed and displacement groups might be partially attributable to the instructions to report force. Also, given the intercorrelation between the two variables, the categorical feedback would be the same for the two feedback criteria in the majority of trials.

A Block $\times$ Group ANOVA on the relative confidence using the feedback-referential definition of performance revealed only a significant interaction, $F(2, 21) = 3.67, p = .04$; the force condition showed a large decrease in relative confidence, whereas the speed and displacement groups continued to show an increase in relative confidence. We had expected the same degree of learning in

the three groups and, therefore, the same decrease in relative confidence. Although we did not find that equivalent decrease, it is clear from a comparison of columns 4 and 8 of Table 2 that the overconfidence in the speed and displacement conditions was significantly less than what was obtained through the force-referential measure on these groups, as demonstrated by the significant interaction in a Block (pretest, posttest) $\times$ Method (force referential, feedback referential) ANOVA, $F(1, 30) = 5.52, p < .026$.

Our analyses of feedback-referential performance led us to conclude that degree of overconfidence depends in part on one's definition of performance. Note, too, that none of our groups demonstrated underconfidence, Runeson et al.'s (2000) hallmark of direct perception. In the next subsection, we examine whether an even more intrinsic performance measure will reveal such underconfidence.

Intrinsic performance. The just-presented analysis supposes that a participant's judgment about confidence is in terms of his or her judgment about performance. Thus, a determination of underconfidence or overconfidence must take into account what the participant is doing. Force-referential performance was defined in terms of explicit task demands ("judge force"), whereas feedback-referential performance was defined relative to implicit task demands. In this section, we go even further in seeking an intrinsic measure of participant performance.

For Table 2 we had defined performance and relative confidence in terms of feedback; Table 3 presents analogous results, but in terms of the variables that appeared to be exploited by a participant on the block in question. So for example, the speed-pretest performance cell of Table 3 is the average of all participants who appeared to base their judgments on speed on that block, as evidenced by a higher percentage correct relative to speed than relative to force or displacement. Similarly, participants in the force-posttest cell had higher percentages correct relative to force than relative to speed or displacement. Put another way, our intrinsic measure of performance is operationalized as the best performance relative to the three variables in question and irrespective of explicit instructions or feedback group membership. Note that a participant can be in one row for the pretest and another row for the posttest.

TABLE 3
Average Performance and Relative Confidence in Experiment 2
Using Exploited Variable as Standard

Exploited Variable	% Correct		Relative Confidence	
	Pretest	Posttest	Pretest	Posttest
Force	73.6	87.4	7.6	-2.8
Speed	76.2	79.4	3.0	6.7
Displacement	68.7	79.9	6.0	8.5

A Variable (force, speed, displacement) $\times$ Block (pretest, posttest) ANOVA on intrinsic percentage correct from pretest to posttest showed a significant increase, $F(1, 42) = 11.71, p < .001$. The same ANOVA on intrinsic relative confidence revealed no significant effects. The lack of significant differences in relative confidence suggests that this measure does not discriminate among groups based on which variable was exploited. More specifically, the lack of an effect suggests that intrinsic relative confidence may not always be diagnostic of the use of a particular kind of variable or mode of apprehension. In our view, the finding that a decrease in confidence can disappear when analyzed with intrinsic measures should be seriously taken into account if one uses confidence measures to distinguish perceptual modes.

Let us turn finally to the performance of individuals. Both the intrinsic performance and relative confidence scores are presented by participants in Table 4; it

TABLE 4
Performance and Relative Confidence for Individuals in Experiment 2
Using Exploited Variable as Standard

Feedback Group/Participant	Intrinsic % Correct		Intrinsic Relative Confidence	
	Pretest	Posttest	Pretest	Posttest
Force				
1	72.2	91.7	-1.5 ^a	-2.1
2	72.2	91.7	-1.8 ^a	-11.6
3	86.1	86.1	-6.3 ^a	7.1 ^a
4	60.0	85.7	12.8 ^b	-1.6
5	75.0	80.6	5.9 ^a	4.1
6	63.3	84.8	18.5 ^b	-9.1 ^a
7	75.0	86.1	25.0 ^a	-5.5 ^a
8	83.3	80.6	-7 ^a	-1.1 ^a
Speed				
9	72.2	77.8	.8 ^a	10.3 ^a
10	69.4	75.0	9.7 ^b	20.7 ^a
11	66.7	75.0	26.2 ^a	18.5 ^a
12	77.8	77.8	13.5 ^a	9.3 ^b
13	75.0	75.0	9.8	15.4 ^a
14	77.8	80.6	-12.1 ^a	10.8 ^a
15	72.2	77.8	2.4 ^b	10.9 ^a
16	69.4	83.3	6.9 ^a	-4.4 ^a
Displacement				
17	77.8	88.9	5.8 ^b	2.4 ^b
18	63.9	75.0	-12.3 ^a	-3.3 ^a
19	77.1	72.2	-2.9 ^b	12.1 ^b
20	75.0	57.1	-4.8 ^a	21.3 ^a
21	58.3	60.0	14.3 ^a	-5.1 ^a
22	55.6	77.8	-4.6 ^b	10.2 ^b
23	57.1	52.8	14.0 ^a	19.1 ^a
24	63.9	72.2	5.5	1.9 ^a

^aIndicates apparent reliance on speed. ^bIndicates reliance on displacement.

conveys a picture somewhat different from that of Table 3, which suggests that underconfidence appears only in the group that received force-based feedback. Table 4 reveals that relative confidence shows large individual differences. Of importance, some participants who exploit variables other than force also exhibit underconfidence. Negative relative confidences that bear the superscripts ^a or ^b in Table 4 are blocks on which underconfidence was seen when the participant's judgment was not based on specifying information. Thus, at the level of the individual, at least, underconfidence is clearly not diagnostic of exploiting specifying information in a perceptual mode.

EXPERIMENT 3

The confidence displayed by participants in a task such as ours is presumably due not only to how well they assess their own performance. Another factor that is likely to influence confidence is the feedback provided by the experimenter. The participant who is told that he or she is correct on 90% of the trials would presumably be more confident than the one who is told of being correct on 60% of trials, irrespective of their actual performance. For example, the overconfidence that participants display when they use the wrong variable in a perceptual judgment is likely to be decreased by feedback that performance is poor. The possible use of confidence judgments as indication of mode of apprehension makes it interesting to know what other factors contribute to confidence judgments.

To test the extent to which confidence judgments depend on the given feedback, we contrived in Experiment 3 a situation in which the feedback on force differed between two groups. In particular, the criterion for what constituted a correct response was modified so as to increase the percentage of "correct" judgments in one group (the encouraged group) and to decrease it in another group (the discouraged group). Encouraging feedback might increase absolute confidence, whereas discouraging feedback might decrease it, both independently of actual performance. Such a change in absolute confidence, in turn, would be reflected in relative confidence measures.

Method

Sixteen new participants were randomly assigned to one of two groups. The 36 visual displays presented were identical to those of Experiment 1, and as in Experiment 1, only force feedback was given. The simulated forces ranged from 329 to 864 N, and participants were again to indicate whether a given force was above or below the average force in the group. However, rather than basing the feedback on the actual mean (583 N), which would have yielded correct feedback for the participants, judgments regarding the forces near the mean force (552–621 N) were always indicated to be *correct* to the encouraged group, and to be *incorrect* to the discouraged group, irrespective of the participants' judgment. This swing set com-

prised 8 out of 36 displays in each block of trials; thus, if participants in the two conditions were judging at random, the encouraged group would get positive feedback on 61% of trials, whereas the discouraged group would get positive feedback on only 39% of trials. If participants in the two groups always correctly categorized the pulls, the encouraged group would get positive feedback on 100% of trials, whereas the discouraged group would get positive feedback on only 78% of the trials.

Results and Discussion

Before examining the confidence judgments, let us examine performance in the categorization task. Again we include in our analysis the data from Experiment 1, which we now label the accurate feedback condition. We first asked whether participants differed in their force-judgment performance. A Block $\times$ Group ANOVA on percentage correct judgments revealed only one significant effect, that of block; the percentage correct categorization increased monotonically over blocks from 63.4% correct to 77.2% correct, $F(5, 105) = 8.87, p < .001$. Feedback groups showed no effect on participants' success in judging force. The averages are plotted in Figure 4.

As to relative confidence judgments, a Block $\times$ Group ANOVA on the relative confidence in the force-referential definition of performance revealed only a significant decrease over blocks of trials, $F(5, 105) = 5.172, p < .001$. The feedback groups did not differ, as is clear from Figure 5. Figure 5 also shows that the decrease in relative confidence did not result in underconfidence. This observation prompted us to consider once again an intrinsic dependent variable as a measure of performance. An ANOVA on the relative confidence intrinsically

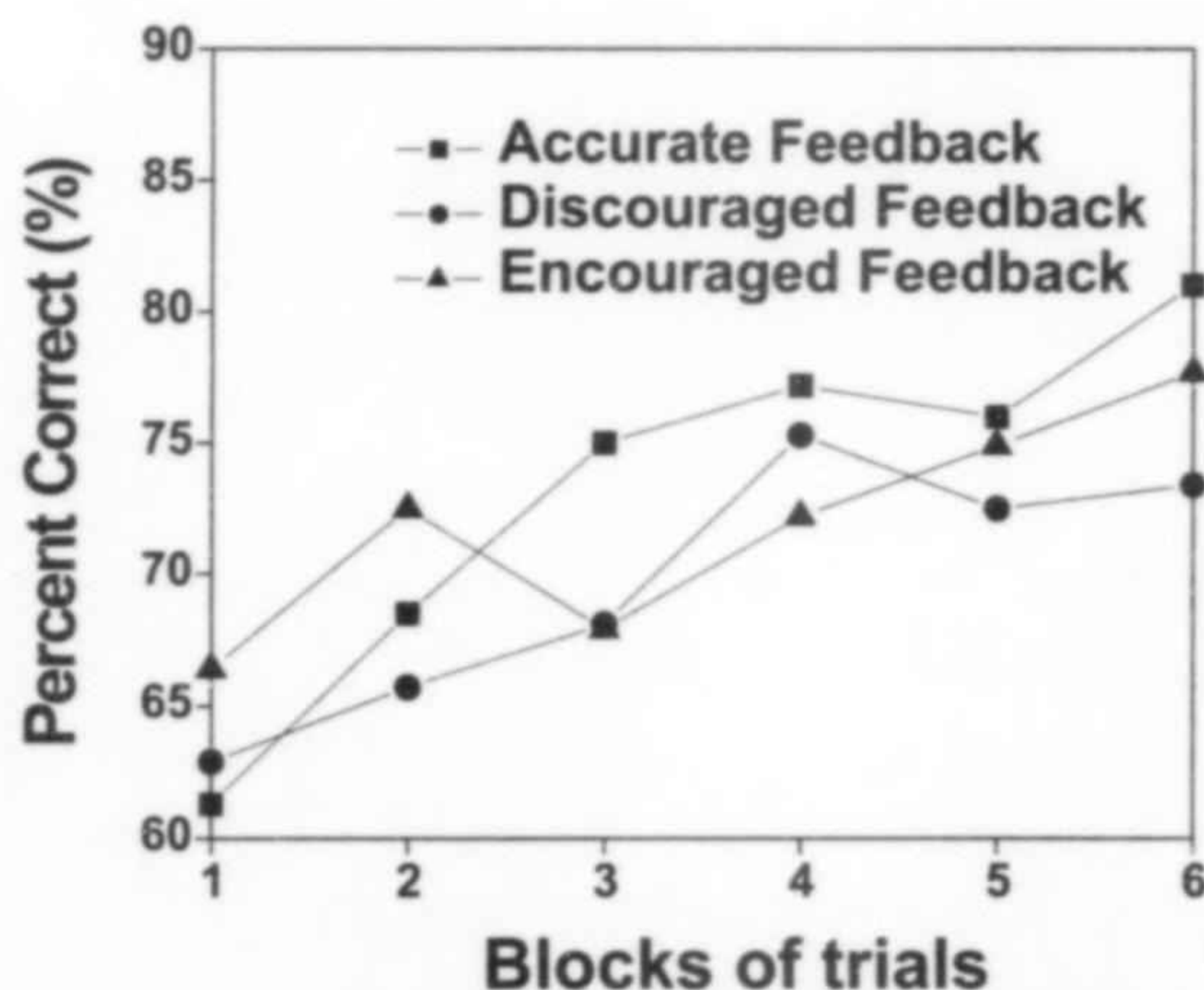


FIGURE 4 Percentage of correct judgments over blocks of trials for the encouraged, discouraged, and accurate feedback groups in Experiment 3.

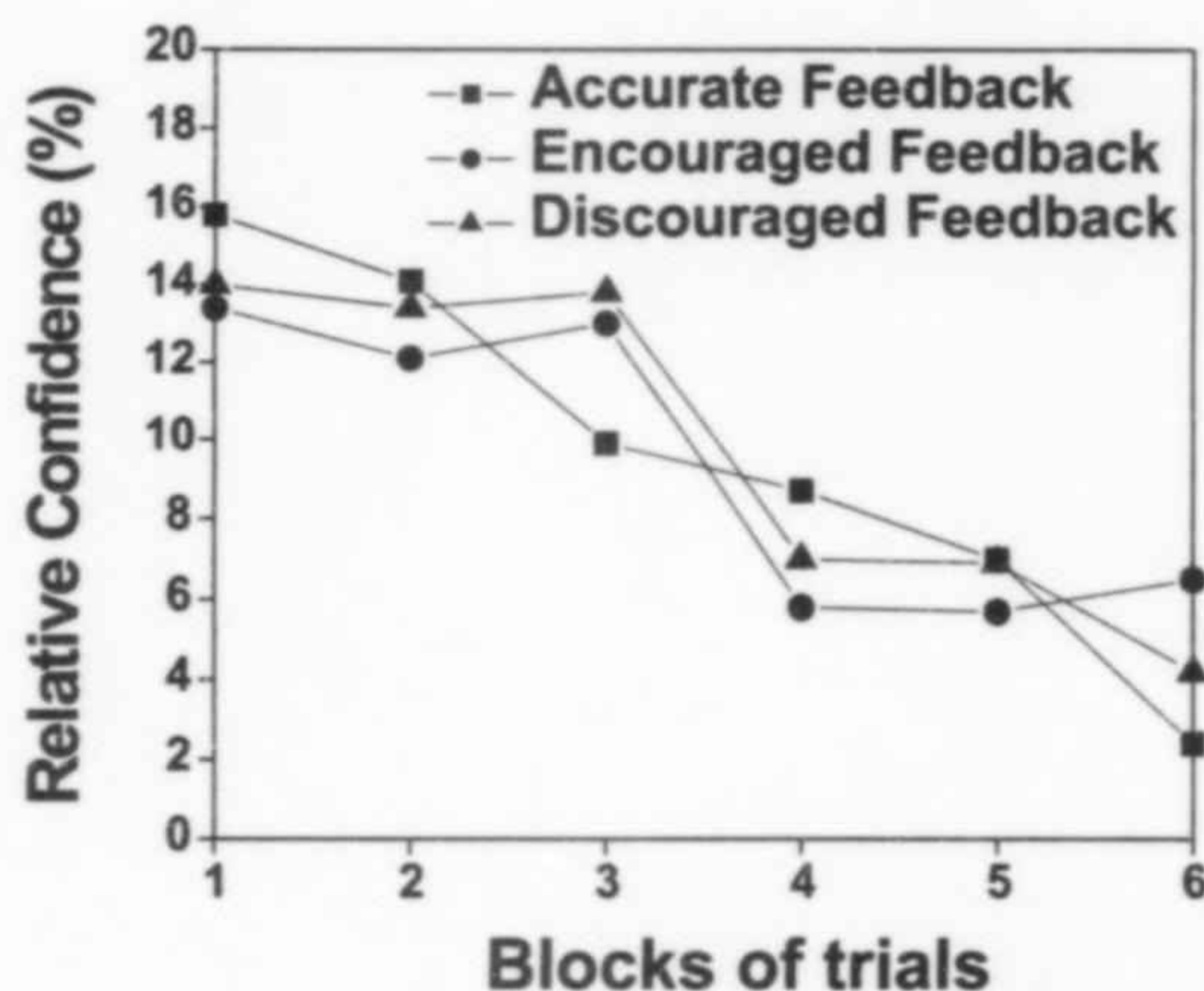


FIGURE 5 Relative confidence judgments over blocks of trials for the encouraged, discouraged, and accurate feedback groups in Experiment 3.

defined also failed to reveal an effect involving feedback group, although predictably, relative confidence was lower.

We conclude that quality of (erroneous) feedback did not have the predicted effect on confidence. Rather than influencing confidence judgments, the feedback may have influenced how they performed the task (e.g., what variable they exploited). We had hoped that giving false feedback only on trials very close to the mean force would have had little effect on performance, but it seems to have been used as genuine feedback, altering variable usage.³

Even if erroneous feedback had tended to affect confidence judgments, an examination of the results of individuals (Table 5) suggests that there may be a confidence trait variable whose influence dominates. We see that on Block 1 (the pre-test), in which feedback had not yet been given, confidence ranged from 61% to 93%. In the remainder of this section we explore how these individual differences are reflected in relative confidence. Because the feedback manipulation had only a minor effect, we ignore condition in the following analyses.

Absolute confidence on Block 1 might be taken as a crude measure of trait confidence, if confidence can be shown to be unrelated to Block 1 performance. We regressed absolute Block 1 confidence on Block 1 performance and found that they were not correlated, $r(22) = .004$, suggesting that Block 1 confidence is a relatively uncontaminated measure of the trait. We then asked whether this trait affected the relative confidence observed on subsequent trials. We divided participants into three groups (high, medium, and low confidence) based on absolute confidence

³This conclusion followed primarily from an analysis of intrinsically defined performance, which was significantly lower with false feedback than with accurate feedback, $F(1, 21) = 4.981, p < .037$, and the difference got larger over blocks of trials, $F(5, 105) = 6.111, p < .001$. We interpret this difference as suggesting that the feedback continually encouraged perceivers to look for better information variables.

TABLE 5
Performance and Absolute Confidence for Individuals in Experiment 3

Feedback Group/Participant	% Correct		Absolute Confidence	
	Pretest	Posttest	Pretest	Posttest
Accurate				
1	66.7	91.7	70.7	89.6
2	66.7	91.7	70.4	80.1
3	75.0	80.6	79.8	93.2
4	42.9	85.7	72.8	84.1
5	69.4	80.6	80.9	84.7
6	33.3	78.8	81.8	75.7
7	63.9	75.0	77.5	80.6
8	72.2	63.9	82.6	79.5
M	61.3	81.0	77.1	83.4
SD	14.9	9.1	5.0	5.7
Encouraged				
9	71.4	85.7	71.2	79.7
10	57.1	65.7	77.0	86.6
11	74.3	82.9	80.2	87.0
12	65.7	77.1	84.7	74.7
13	51.4	71.4	86.3	83.7
14	68.6	68.6	74.3	80.6
15	51.4	71.4	61.0	74.0
16	62.9	64.7	75.2	73.4
M	62.9	73.4	76.2	78.0
SD	8.8	7.8	8.0	5.5
Discouraged				
17	77.1	82.4	82.5	90.4
18	73.5	77.1	77.0	73.4
19	65.7	60.0	69.5	72.2
21	65.7	85.3	78.7	85.8
20	62.9	71.4	88.5	98.6
22	60.0	82.9	92.1	90.4
23	45.7	77.1	83.6	84.3
24	77.1	79.4	79.4	76.5
M	66.0	77.0	81.4	84.0
SD	10.4	8.1	7	9.3

judgments in Block 1. A Block (2–6) $\times$ Group ANOVA on relative confidence (using the force-referential performance measure) showed a marginally significant effect of trait, $F(2, 21) = 2.81, p < .083$. We also examined the intrinsic measure of relative confidence. A Block $\times$ Group ANOVA revealed a significant main effect of trait confidence, $F(2, 21) = 3.88, p < .037$, suggesting that relative confidence judgments were influenced by individual differences in a systematic way. Averages are depicted in Figure 6. The group that had the lowest absolute confidence in

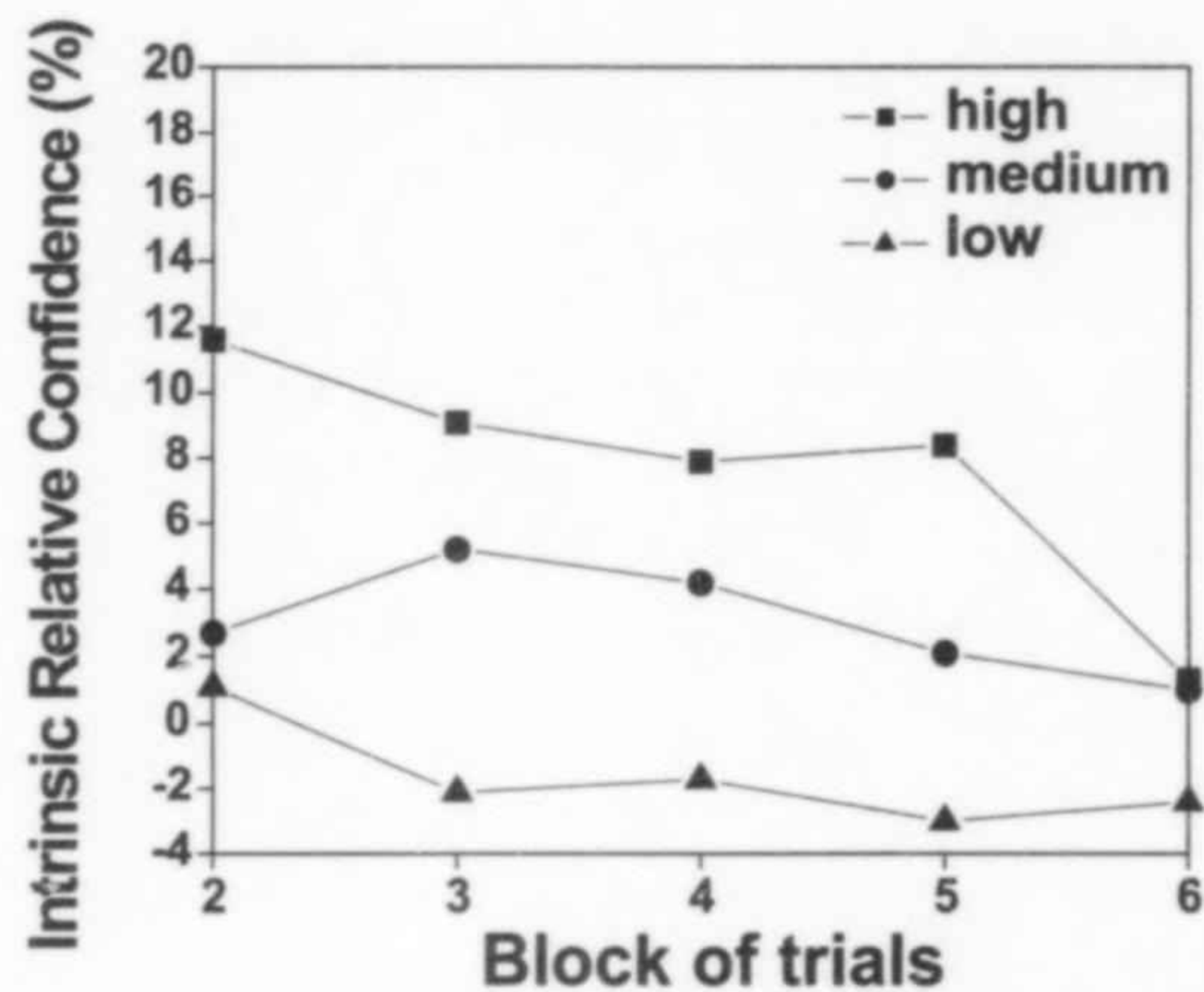


FIGURE 6 Intrinsic relative confidence over blocks of trials for the low-, medium-, and high-trait-confidence groups as operationalized by absolute confidence levels on Block 1 in Experiment 3.

Block 1 was on average underconfident, whereas the more confident groups had an average relative confidence in the overconfidence range.

To summarize, in Experiment 3 we attempted to manipulate confidence by giving false feedback about performance. Our goal was to establish whether factors besides mode of apprehension determine confidence. That manipulation failed, but our attention was called to large individual differences on Block 1, in which no feedback had been given. This absolute confidence was unrelated to performance. We observed that participants who showed high confidence on Block 1 tended to show relative overconfidence on later blocks, whereas participants who showed low confidence on Block 1 tended to show relative underconfidence on later blocks. In short, trait factors, which are independent of both variable usage and mode of apprehension, seem to affect relative confidence.

GENERAL DISCUSSION

In three experiments we explored some characteristics of relative confidence to see its strengths and weaknesses as an index of the type of processing that perceivers engage in when they make judgments about events, as proposed by Runeson et al. (2000). We were particularly interested in the extent to which factors other than mode of apprehension could influence relative confidence. We reasoned that it would be important to take such factors into account if using particular values of relative confidence, and relative confidence in general, as an indicator of whether a perceiver is in an inferential or direct perceptual mode.

The task we used was the judgment of relative pulling force. In Experiment 1, we adapted the Michaels and de Vries (1998) pull-perception paradigm to permit

the evaluation of confidence; participants were asked to make categorical judgments (regarding whether the pulling force was greater than or less than average) and to estimate the confidence they had in their judgment. The results replicated two of Runeson et al.'s (2000) basic empirical effects: that feedback improved percentage of correct judgments over blocks of trials and decreased the degree of relative confidence. However, we did not find average underconfidence, the hypothesized hallmark of direct perception, as Runeson et al. saw on later blocks.

The higher overconfidence found in our experiment led us to propose an alternative explanation of the decrease in confidence. If confidence judgments are assumed to veridically reflect the accuracy with which observers detect the optical variable that they use, whatever variable that may be, they might appear overconfident before practice because they tend to use nonspecifying variables, which would not permit accurate performance. Furthermore, overconfidence might then disappear with practice merely because observers change their variable use and come to rely on specifying variables, which permits best performance. This hypothesis was tested in Experiment 2.

If, as argued, the average overconfidence was due to some participants' use of nonspecifying variables, fostering reliance on nonspecifying variables should increase relative confidence. To test this, in Experiment 2 we tried to alter performance level by giving participants feedback based on nonspecifying variables. This manipulation succeeded in steering participants toward relying on the variable they received feedback on, regardless of whether it specified the to-be-judged property, force. More important, the manipulation indeed led to an increase in overconfidence, supporting the hypothesis that the decrease in confidence in Experiment 1 had been due to convergence on a specifying variable. This hypothesis was further confirmed by the finding that no effects regarding relative confidence were observed when we used intrinsic measures, that is, when we measured confidence relative to the variables that observers appeared to use, rather than relative to the explicit task variable.

In Experiment 3, we tried to manipulate absolute confidence directly by giving false feedback about performance, but we did not succeed. This is, of course, encouraging for the use of relative confidence in distinguishing modes of apprehension because the fewer factors that influence relative confidence, the better. Unfortunately, however, we observed large individual differences in absolute confidence on Block 1, and they were not correlated with performance. We then split observers into three groups based on their absolute confidence level in Block 1. A significant effect of group suggested that what seems to be a trait variable heavily influenced the relative confidence.

To summarize, our finding that confidence judgments do not appear to merely reflect feedback is encouraging for the use of confidence judgments in distinguishing the modes of apprehension, whereas the finding of large individual difference and the finding that the decrease in confidence can be due to convergence on specifying information are not. What are the implications of these findings concerning

confidence judgments for the mode transition proposed by Runeson et al. (2000)? And, more generally, what are the implications for ecological theories of perceptual learning? Before we turn to these main questions, we want to make a few prior observations concerning task-defined versus intrinsic performance measures, quantitative versus binary feedback, and inference versus perception.

Task-Defined Versus Intrinsic Performance Measures

The skeptic might wonder how seriously one should take conclusions based on arbitrary definitions of performance. Arguably, we asked people to perform a task, then ultimately scored their performance without attention to the explicit task. We believe we can defend this apparently unorthodox move.

First, given that participants were asked to assess their certainty in the accuracy of their judgments, *their* standard was surely whatever they were doing, irrespective of its agreement with how we as experimenters defined success. That is, a participant presumably judges the likelihood of being correct on the basis of the attended-to variable: If it is extreme (i.e., well above or below its mean), the perceiver is likely to be confident; if it is near its mean, the perceiver is likely to be uncertain. If the experimenter chooses a performance measure different from the participant's standard, *relative confidence* becomes a measure of the relative mismatch between what participants are doing and what the experimenter assumes they are doing. In that sense, one might argue that an intrinsic performance measure is less arbitrary than one rooted in explicit task demands.

How to define and measure what perceivers are doing and how well they are doing it should not be considered to be a simple business. This is illustrated by Gibson's (1966) arguments about the meaning of geometric illusions (see also Michaels & Carello, 1981, p. 92). When a perceiver's judgment about the length of a line, say in the Müller-Lyer figure, is different from the scientist's measure, the conventional interpretation is that the perceiver is in error. Gibson (1966, p. 313) remarked, however, that it is the scientist who is not measuring the variable that the perceiver exploits in reporting length. Presumably, perceivers are reliably detecting whatever they detect. Thus, finding poor performance in length estimation in a Müller-Lyer task can be simply the result of bringing to bear an arbitrary standard. Crisp operational definitions of performance may simplify experimental work, but they can obscure more fundamental principles.

Quantitative Versus Binary Feedback

In our attempt to replicate Runeson et al.'s (2000) findings in the pulling-force paradigm, we adapted the pull-perception paradigm to Runeson et al.'s measurement and feedback procedure. Feedback was always categorical, given as "correct" or "incorrect." As such, it offered a restricted range of information that did not allow for much perceptual discrimination. A comparison of the degree of improvement

in (extrinsically measured) performance with the results of Michaels and de Vries (1998) indicates that performance benefits much more from continuous than from categorical feedback. The lack of informativeness of the categorical feedback may have slowed the march of learning, and thus possibly the march toward underconfidence. More learning may have led to degrees of underconfidence that were more in line with those reported in the collision paradigm.

Perceiving Versus Inferring

Whereas the Helmholtzian tradition holds that all, or at least most, of perceiving is a matter of inference, ecological psychologists hold that perceiving and inferring are different, and that inferring, if it happens, is subsequent to perception. As outlined in the introduction, one difference that often goes together with the distinction between inferring and directly perceiving is the type of variable that the respective processes are thought to rely on. Inferences are often said to be based on so-called lower-order variables, whereas direct perception is said to be based on analytically complex or higher-order variables. The mode transition hypothesis, however, refers to more than to this difference. Beyond the use of different types of variables, the mode transition refers to a qualitative distinction in the mode of apprehension. Perception being characterized by an "immediacy" and directness of the experience of the apprehended property, and inferences being characterized as a "reasoning" process (Runeson et al., 2000, pp. 528, 534).

Although these two distinctions—type of variable and mode of apprehension—are often thought to go together, this need not always be the case. Perceivers could very well detect higher-order information that specifies some property and subsequently engage in thought-like processes. It is equally feasible that observers have a direct impression of, say, speed, on the basis of a variable that specifies speed, which is often said to be a lower-order variable. More extremely, one could claim that observers perceive force, without need for inferential processing, on the basis of speed-specifying variables (e.g., Michaels & de Vries, 1998). We argue for the independence of mode and variable type and thus accept the possible reliance on supposedly different types of variables in each perceptual mode.

One reason to view variable type and mode of apprehension as independent is that, as widely argued, the distinction between lower-order and higher-order variables might not be viable; it might not be possible to rigorously categorize variables as higher order and lower order. This leaves any claims that a particular mode relies on a particular type of variable either vacuous or circular. One could get around this critique by claiming that the mode distinction refers to specifying versus nonspecifying variables rather than to higher- versus lower-order variables. Such a coupling between mode of apprehension and specifying and nonspecifying variables, however, does not fare much better.

First, the all-or-none characterization of perception as related to specifying variables and inference to nonspecifying variables seems to make learning into an

all-or-none phenomenon. The catastrophic discovery of specifying information abruptly shifts one from inference to perception. The ability to perceive some property, therefore, cannot improve; it can only come into existence. Although this is possible, our first impression would be that it would have to be an unguided trial-and-error process.

Second, and relatedly, the identification of perception with specifying information renders perception vulnerable to an a posteriori determination that it was merely inference. For example, say one perceives the distance of a falling object by exploiting the specificity of optic-array acceleration to that distance. A falling object accelerates at 9.8 m/s^2 , so the optical acceleration of an object falling at eyeheight specifies distance. Surely the discovery that gravity is other than 9.8 m/s^2 in some places should not render any perception of distance that exploited optical acceleration to have been merely inference. Similarly, perception is what it is, and determinations that there are natural or mischievous anomalies with the information do not change the character of perception. Leaving perception ever open to reclassification as inference lets perception slip back into the realm of true (and possibly even false) belief. In short, we argue that changes in variable use, without restrictions to possibly different types of variables, can occur in both modes of apprehension, which leads us back to one of our main questions.

What are the implications of our results for the mode transition hypothesis proposed by Runeson et al. (2000)? One of the difficulties of the mode transition hypothesis is its testability. How can an experimenter tell whether an observer apprehends in an inferential or perceptual mode? With the testability being such a delicate question, probably requiring several converging operations, one would certainly hope that confidence judgments would be one such converging operation. Unfortunately, our results mainly add concern with regard to this use of confidence judgments, thereby indicating that further methods to distinguish inferential and perceptual functioning are needed.

If one assumes that methods to distinguish the modes can be established, then the mode transition theory of learning would have to face a further challenge, namely, to explain the mode transition. That is, however complicated the basis of the observation, it is unsatisfactory just to observe that a transition has occurred. How does a transition occur? Answering this question may prove difficult. Moreover, for theories that entail a mode transition, the challenge is inevitable.

On a positive note, our finding that the decrease in confidence can be explained by mere convergence on specifying variables, with perceivers performing in a direct perceptual mode throughout, suggests that learning results such as those in the experiment presented here can be addressed without resorting to a mode transition. Our expectation is that a lawful account of how people change only in which variables they use might encounter less severe scientific challenges than an account of how a mode transition might occur.

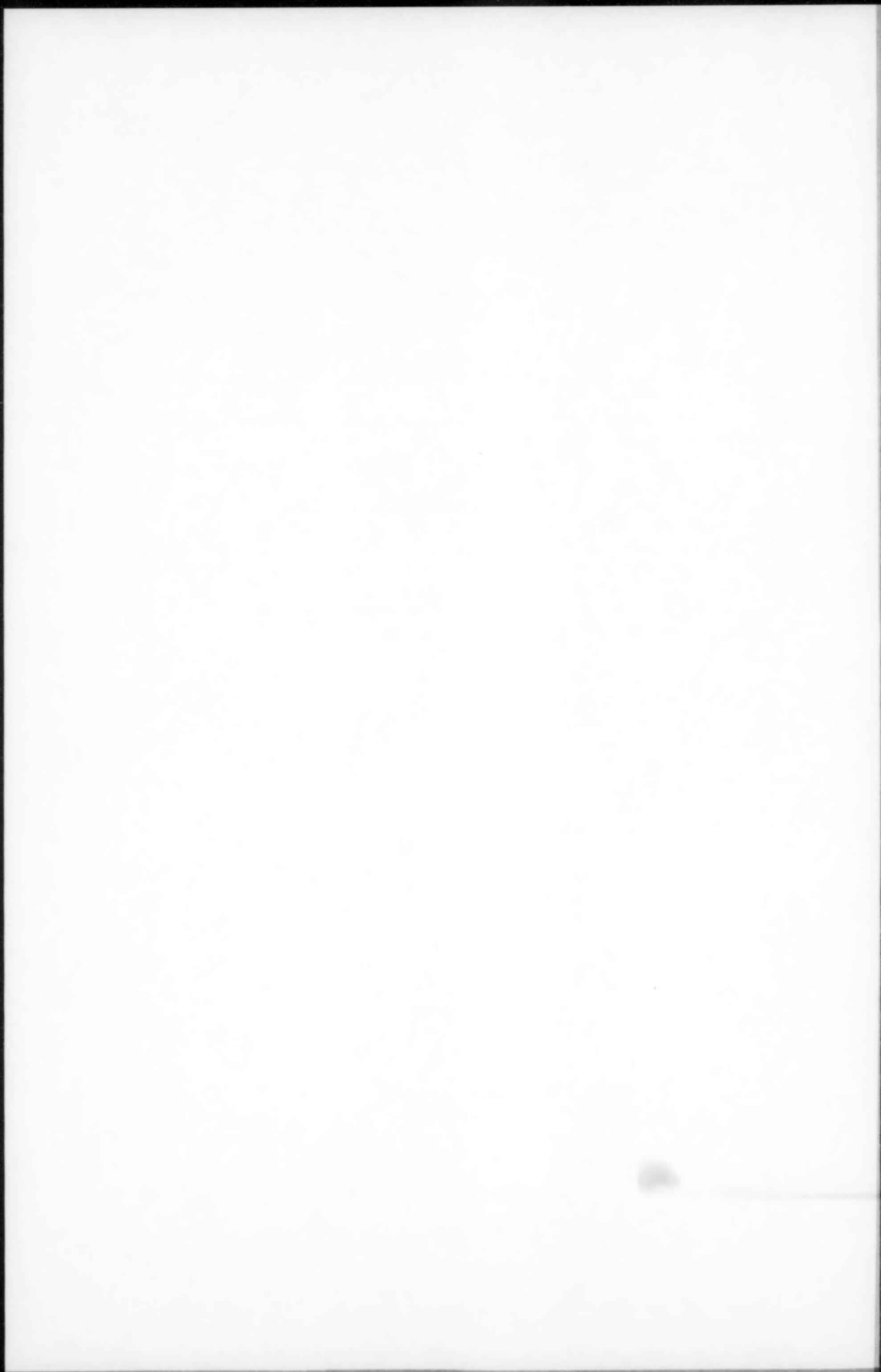
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Carrying Babies and Groceries: The Effect of Moral and Social Weight on Caring

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Two carrying tasks were used to assess the effects of physical, social, and moral weight on the care with which actions are taken. In Experiment 1, observers rated point-light walkers traversing uneven terrain carrying 3 unseen objects: a child, a bag of equally weighted groceries, and a bag of equally weighted trash. Kinematics of walkers carrying children were rated as more careful. In Experiment 2, perceived and actual maximum stepping height (MSH) was determined while carrying a child, a bag of groceries, and an empty bag. Perceived MSH was reduced by greater physical and moral weight, but actual MSH was equal with groceries and child, suggesting a difference between individual judgment and joint action. Implications for caring, carrying, values, social perception, and the relation of judgment and action are considered.

Carrying an object while climbing a hill or stepping from rock to rock across a creek is a delicate, demanding task. Does the nature of the object carried affect the demands of the task and the delicacy of the action? For example, does the difference in moral weight between a child and a bag of supplies affect the placing and timing of one's steps? Or, does a social difference in one's load (e.g., a complaining child rather than a pleasant one) modulate stepping movements? Do such factors affect judgments about what movements should be attempted?

The act of *carrying* is almost by definition an act of *caring*. One does not pick up and move things of no concern. Humans have carried babies, tools, foodstuffs, waste, small animals, clothing, and innumerable other items from time immemorial. Taylor and colleagues have argued that humans have a deep-rooted concern for others, revealed in activities of tending and caring (Taylor, 2002; Taylor et al.,

2000). They argue that there is evidence indicating that caring and tending activities have influenced the evolution of the brain and, thus, are now fundamental propensities of neural biochemistry that play a critical role in how humans respond to stress.

Carrying may be a basic activity of humans and caring may be a fundamental dimension of social action, but they have been studied surprisingly little by psychologists. In particular, little is known about how caring shapes particular actions. Studies on caring (e.g., Altshuler, 2001; Batson, 1990; Buck, 2004; Hart & Fegley, 1995; Miller, 1994) usually consider it at high (i.e., abstract) levels of action identification (Vallacher & Wegner, 1987). Sometimes studies consider specific helping behaviors as a measure of caring, but the focus is on the presence or absence of the behavior rather than on the manner in which it is done. Developmental psychologists have considered caring in terms of how sharing and helping develop (e.g., Mussen & Eisenberg-Berg, 1977) and, occasionally, have considered carrying children, usually in terms of how the child is affected by it (e.g., Anisfeld, Casper, Nozyce, & Cunningham, 1990; Field, Malphurs, Carraway, & Pelaez-Nogueras, 1996).

Studies of the physical act of carrying tend to focus on issues of efficiency, effort, and safety (e.g., Kinoshita, 1985; Reneman, Jaegers, Westmaas, & Göeken, 2002). Studies of carrying by social psychologists are more likely to be about carrying weapons than carrying children (e.g., Shaw & Skolnick, 1999). Studies of caring *and* carrying are rare. The only clear example we have found are the studies of Kokubun (1999) and colleagues (Kokubun et al., 2003), who have investigated the care with which children carry items such as trays with glasses of water on them.

The experiments presented here consider the care with which commonly carried objects such as children and groceries are transported. More specifically, we consider whether differences in moral and social weight affect the care with which actions are performed. A number of studies suggest that actions vary as functions of the intentions, emotions, evaluations, and expectations of the person engaging in the action (e.g., Dittrich, Troscianko, Lea, & Morgan, 1996; Gardner, Mark, Ward, & Edkins, 2001; Knoblich & Flach, 2001; Montepare & Zebrowitz, 1993; Neumann, Förster, & Strack, 2003). Perhaps the most relevant of these are Runeson and Frykholm's (1983) studies on lifting, one aspect of carrying. They found that observers of point-light films of people lifting boxes could detect an intention to disguise the true weight of the box under certain conditions. This detection of a social constraint (i.e., experimenter's instructions to disguise) was possible, they argued, because motion patterns necessarily reflect the physical forces constraining them (what they referred to as the KSD [kinematics specify dynamics] principle). The tension between physical weight and social intention made it possible for observers to judge with considerable accuracy both (true) weight and (false) intent.

Do moral and social constraints alter the dynamics of action in ways revealed in kinematics when those constraints are not directly opposed to physical constraints, as they were in Runeson and Frykholm's (1983) studies? Valenti and Costall (1997)

found evidence that observers used their perception of the care with which boxes were carried to estimate the boxes' weight. More directly, a study by Schappert, reported in Hodges (1999), presented observers with point-light films of mothers carrying their own child, another person's child, or a bag of groceries, all equally weighted, across a set of uneven steps. Although observers could see only trunk and leg movements and did not know something was being carried, they rated walkers as more careful on children trials than on groceries trials. A second hypothesis, based on evolutionary theory, that one's own child would be carried more carefully than another's, was not supported. These conclusions are limited, however, by the small number of parents carrying objects and the unvarying order in which objects were carried (groceries, own child, other child, respectively).

CARING, CARRYING, AND VALUES

Within an ecological framework, caring can be defined as a concern to realize values in the carrying out of some task. Hodges and Baron (1992) explored an ecological approach to values, proposing that actions are always constrained by multiple values that are in tension with one another but that function cooperatively. There is no fixed, hierarchical ordering of values. Instead, values function as a heterarchy (Cohen, 1992; Turvey, 1977); that is, they mutually constrain one another so that each of them is realizable in the long run only if all are equally honored. Thus, in a carrying task this might mean that speed (i.e., the value of efficiency) would yield to safety (i.e., protecting the value of the object carried). That is, the priority of safety would demand going more slowly. However, this would not always be the case because in other situations speed may assist safety (e.g., exiting a burning building).

Previous studies have suggested that safety concerns may reduce perceptual accuracy. For example, drivers deciding whether to pull into oncoming traffic tend to be conservative: They act as if the other vehicle will arrive sooner than it does (Hesketh & Godley, 2002). Similarly, Jiang and Mark (1994) found that participants' judgments about the crossability of crevices became more conservative as the depth of the crevice increased. However, in other cases safety enhances accuracy. Konczak, Meeuwssen, and Cress (1992) studied people's ability to perceive their maximum stepping height (MSH). They found that older persons were more accurate in perceiving their action capabilities than younger persons. They interpreted this as ecologically appropriate because the ability of older participants to compensate for misjudgments is more limited. This suggests that people who need to be more careful will be more accurate in judging which actions to take.

Numerous larger issues frame our studies. What makes an action caring or careful? Do careful actions entail the same motions as uncaring or careless actions, except that their intention is different? Or does caring change the manner and method of movement? If one intends to care, does this change the content of what

is done, the context in which it is done, or both? Is the intention to care a matter of consciousness, of tacit intentionality, or both? Or is being careful less a matter of personal disposition and more a matter of task demands, or, better yet, of the fit between demands and dispositions? Finally, what is the origin of caring? In one sense, all motivated action is marked by caring. From this perspective, bacteria and all other animate beings care for themselves and their surroundings. In a quite different sense, the one highlighted by Taylor (2002), caring may characterize many fewer actions and be much more species specific. Although our studies do not begin to address all of these issues, they may provide a useful entry to them.

In summary, our studies explore two general issues. One is the possibility that moral and social weight might affect the care with which tasks are carried out in ways perceivable by others (Experiment 1) and by the person engaging in the action (Experiment 2). Second, we considered the relation of values, namely accuracy and safety, in judgments about which actions are possible and should be attempted when carrying loads that vary in their physical, social, and moral weight. Experiment 1 is similar to Schappert's study of parents carrying children and groceries reported in Hodges (1999), but with a more controlled design. Experiment 2 is similar to Konczak et al.'s (1992) study of MSH, except that the climbers were carrying objects and those objects varied in value.

Both the MSH task and the uneven terrain task put stress on the physical system, a requirement for demonstrating KSD type effects, but adding the weight of something carried does so even more. If not sufficiently careful, parents walking or climbing might fall, which would have physical, social, and moral consequences (e.g., damage, embarrassment, injury to others).

EXPERIMENT 1

Eighteen parent-child dyads were recruited and paid \$20 for participating in two tasks. The tasks were described as being about how various household items are carried. The first task was used to prepare the materials (i.e., visual displays) for Experiment 1; the second task constituted Experiment 2.

Method

Overview and hypothesis. Each parent was filmed carrying his or her child, a paper bag of groceries, or a paper bag of trash across uneven steps with gaps between them. Each parent wore reflectors on the shoulder, elbow, hip, and both knees and ankles on the side facing the camera. Point-light films of walkers were presented to observer participants who rated the carefulness of walking. Objects carried were not visible.

Our hypothesis was that point-light walkers would be perceived as stepping more carefully when they were carrying children than when they were carrying

equally weighted groceries or trash. In addition, we expected that groceries might be perceived as being carried more carefully than trash. The bases for these hypotheses were that a child has more moral weight than groceries or trash, whereas groceries have more social value than trash.¹

Preparation of visual displays. Eighteen parents (6 fathers and 12 mothers) participated as point-light walkers. Five of the children were girls and 13 were boys.

Parents were measured for leg length (hip bone to floor). Their children were weighed, and trash and groceries bags were adjusted to be equal to each child's weight. The trash actually had some padded weights in the bottom of the bag and coffee grounds, papers, empty drink bottles, and torn paperback books on top. It had a slightly unpleasant odor. Each parent was filmed carrying the groceries, the trash, and his or her child in a specified order across a series of five stairs that were, in order, 30, 41, 20, 46, and 30 cm high, separated by gaps of 23 cm. Across all point-light walkers, order of items carried was counterbalanced. The task was done in an aerobics studio with wood flooring using sturdy plastic steps typically used in aerobics exercises (0.46 m $\times$ 1.54 m $\times$ 0.10 m). The steps could be adjusted to varying heights by stacking fitted plastic support frames about 5 cm thick under each end of the steps. Parents were instructed to lift the object from the floor, stand still briefly, then to begin stepping across the steps using alternating legs. Parents carried the objects in their preferred arm on the side away from the camera. Thus, some parents carried the children left to right and others reversed, but the heights of the steps were always ordered the same. All items were carried in an identical manner (preferred arm underneath, other arm providing support to back of child or the bag containing groceries or trash).

After filming was complete, we discovered that two walking sequences had not recorded properly and that 2 point-light walkers had not followed instructions about holding all the objects in a similar manner with two hands. We omitted films of these 4 point-light walkers and 2 others chosen randomly to maintain the counterbalancing of the items carried. Thus, observer participants saw 12 point-light walkers carrying the three objects. The mean age of the 12 children being carried in the included visual displays was approximately 21 months (range = 9–35 months), and the mean weight was 11.3 kg (range = 8.2–14.5 kg).

Each of the 36 displays (12 walkers, 3 objects) was transformed into a QuickTime movie, which was then digitally edited on Final Cut Pro 3.0 to create a

¹In our view values are not intrinsic to objects (e.g., Reed, 1996) or persons (e.g., Rokeach, 1973; Schwartz, 1992) but are about relationships and the demands that the ecosystem places on those relationships (Hodges & Baron, 1992). We adopt the simplification for ease of presentation. The term *social value* in this context would include the aesthetic, economic, and cultural worth of an item. For example, as a society we might prefer pleasant children to complaining ones, or fresh food to old, partially eaten food. Moral obligations regarding children and food are not reducible to such preferences.

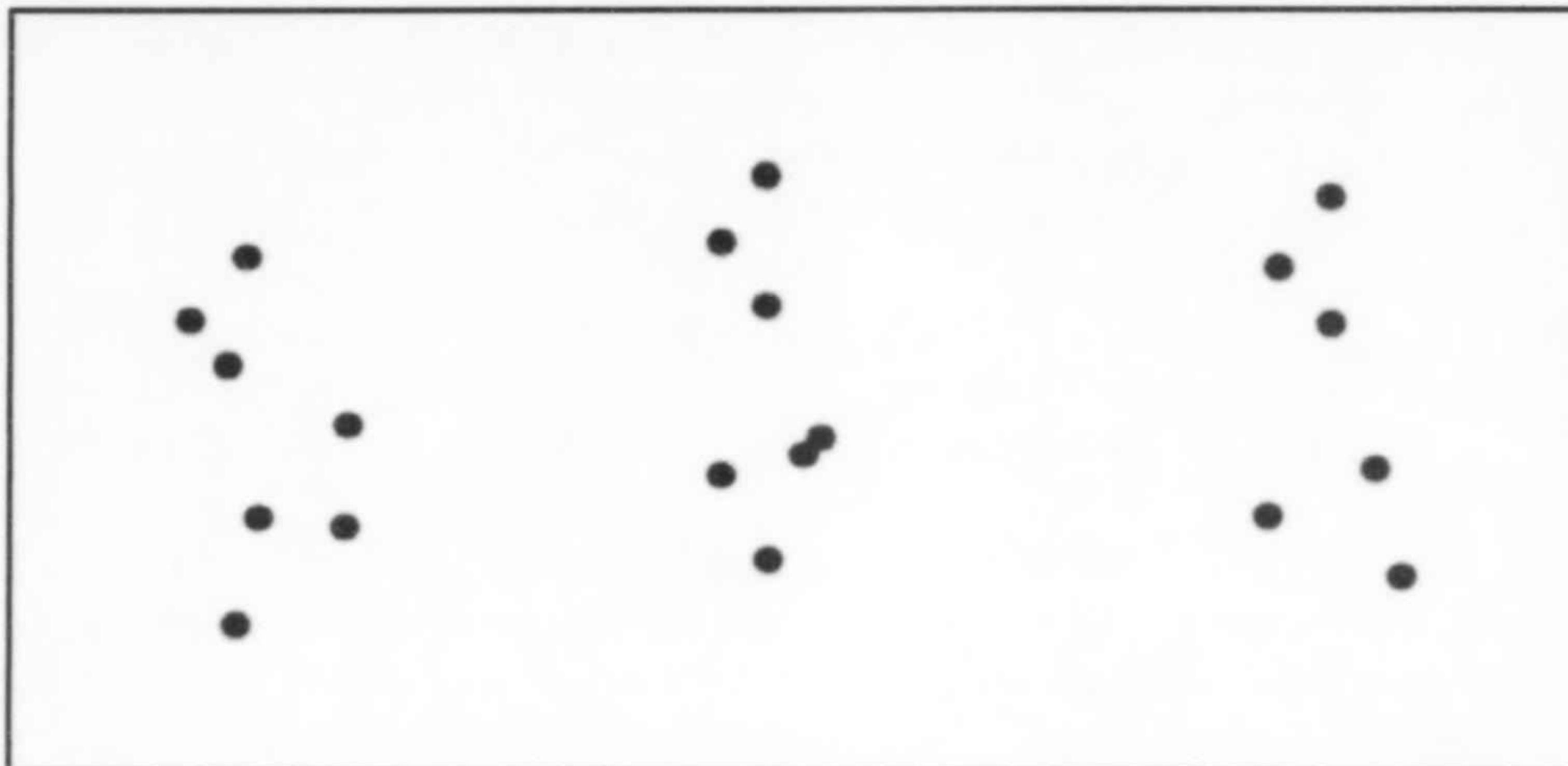


FIGURE 1 Three frames sampled from one stepping sequence by a point-light walker in Experiment 1. Dark and light are reversed from displays shown to participants.

film of white dots that tracked the point-light dots frame to frame. This allowed the presentation of the motions of the point-light dots separate from the rest of the film; only the point-light dots were visible against a black background. The appearance of the displays is illustrated in Figure 1 by three static moments sampled from one sequence of one walker, but with dark and light reversed. Films for parents who had walked from right to left were inverted so that all walkers appeared to move from left to right. The portion of the film showing the lifting of the object was edited out because of excessive variability in how this was done. Thus, walkers were seen standing briefly then walking across the steps.

Participants and procedure. Three randomized orders of these 36 movies were inserted into a PowerPoint presentation with two additional displays from omitted walkers presented as practice trials. The 36 movies presented 2 of the 12 different walkers carrying the three objects in one of six orders: trash (T), groceries (G), child (C); TCG; GTC; GCT; CTG; and CGT. Within each presentation order, all of the trials (one for each object) of a given walker were blocked together, but the order of trials within a walker (trash, groceries, child) was counterbalanced across the three presentation orders. The blocking by walker was done to make it somewhat easier for participants to perceive any differences within a given walker because differences between walkers tend to be much larger. Participants viewing the presentations were not informed about these aspects of the procedure.

Undergraduate students (21 women, 1 man) viewed one of three orders of presentation (7, 7, and 8 participants per order) of the point-light walkers. They received class credit for their participation. The movies were presented by an over-

head projector to small groups of 2 to 7 students. Instructions provided a brief description of point-light displays and then stated the following:

In all the film clips you will see, a person is engaged in walking across uneven terrain where there is some danger of falling. Thus, they always have to walk carefully. However, on some of the film clips the person may have reason to walk more carefully than they do on other ones. What we would like you to do is watch the person in each film clip and indicate how carefully the person was walking.

They were then instructed, "You may not find it easy to decide, but do the best you can. Just go with the first impression that you have." After each film clip was shown, participants rated carefulness on a 6-point scale ranging from 1 (*somewhat careful*) to 6 (*very careful*). After making their carefulness ratings, participants answered six brief questions about the task (e.g., could they tell the gender of walkers, and did any of the walkers seem to be injured, carrying something, or careless?).

Results

A 3 (object: trash, groceries, child) $\times$ 6 (order of carrying: TGC, TCG, GTC, GCT, CTG, CGT) $\times$ 2 (walker: first, second) repeated measures analysis of variance (ANOVA) was done. An a priori alpha of .01 was adopted for all significance tests.

The results for mean carefulness ratings are presented as an Object $\times$ Trial matrix in Table 1. Trial 1, for example, refers to the first item walkers carried across the steps (without regard to specific orders of carrying and specific walkers). As predicted, parents were perceived as significantly more careful when carrying their children than when carrying groceries or trash, $F(2, 42) = 56.19, p < .001, \eta_p^2 = .73$. Pair-wise comparisons (least squares difference) indicated that the child versus groceries difference was significant ($p < .001$) but that the groceries versus trash difference was not ($p = .075$).

TABLE 1
Mean Carefulness Ratings by Object and Trial for Experiment 1

Trial	Object Carried			M
	Child	Groceries	Trash	
1	4.73	3.83	4.65	4.40
2	3.03	3.57	3.30	3.30
3	4.14	3.02	2.14	3.10
M	3.97	3.47	3.36	3.60

There was also an effect for trials: Walkers were perceived as being more careful with the first object carried than the second or third, $F(5, 105) = 46.77, p < .001, \eta_p^2 = .69$. The Object $\times$ Order of Carrying interaction effect was significant, $F(10, 210) = 55.77, p < .001, \eta_p^2 = .73$, suggesting that the novelty of the task may interact with the task of carrying a particular object. All other significant interaction effects involved individual differences among particular walkers.

One heuristic that participants might have used to judge carefulness was the speed with which walkers moved. However, mean times for child, groceries, and trash (5.38, 4.96, and 5.02 sec, respectively) were not significantly different, $F(2, 22) = 1.06, p = .36$ (one-way repeated measures ANOVA), and the correlation between carefulness ratings and time was not significant ($r = .10, p = .55$). Overall speed did not predict carefulness ratings.

In answering the postratings questionnaire, 11 participants reported they had thought something was being carried (at least on some trials), 7 said they had not, and 4 gave ambiguous responses. Several mentioned that the position of the lights on the arm (i.e., elbow) or the lack of relative movement of upper body lights was the basis of their sense that something was being carried. Two participants wondered if some walkers were carrying something "heavy" or that could "spill," and one wondered if a baby was being carried. These answers should not be over-interpreted: In response to a question about whether any walkers appeared injured, about one third answered affirmatively although no walkers were injured.

Discussion

Walkers carrying children are perceived as being more careful than when carrying groceries or trash. Walkers carrying groceries are not perceived as more careful than when carrying trash.

The substantial amount of variance accounted for by the order effect and Order $\times$ Object interaction indicates the desirability of including a few practice trials to stabilize walker behavior. If one considers the results reported for Trial 3 in Table 1, which was the last time each object was carried, the pattern across objects is exactly that which was predicted.

The results support the hypothesis that moral, and perhaps social, dynamics influence kinematic variables that can be perceived by others. However, alternative accounts are possible. For example, walkers might be perceived as more careful when carrying children because children are animate beings (vs. relatively immobile groceries or trash) or because children are more fragile (i.e., would incur more damage in a fall), rather than because they are morally or socially more valuable. Although many variables other than moral or social value, abstractly assigned, are likely to affect carefulness ratings on any given occasion, it is significant that brief kinematic sequences reveal something of the *content* of what is carried and the care afforded that content.

Realizing that carefulness depends on many factors leads to a more general point, one that is central to a values-realizing approach to perception and action (Hodges & Baron, 1992). There are always multiple values—safety, accuracy, comfort, for example—that affect the shape of any particular action. There are multiple levels of constraints on action, which is the focus of Experiment 2.

EXPERIMENT 2

Overview and Hypotheses

This experiment explored the perception and action of the individuals carrying items, rather than others' perceptions about them. Participants estimated and then attempted their MSH while carrying their child, groceries, or an empty grocery bag. The experiment was similar to Konczak et al. (1992) but with two key differences: (a) participants held an object, and (b) the objects varied in moral, social, and physical value. The empty bag condition provided a means for assessing the effect of increased physical value (i.e., greater weight) of the groceries and child; it also allowed a comparison with Konczak et al.'s results. An issue of particular interest was how participants would balance the relation between safety and accuracy.

We tested three hypotheses. First, both perceived MSH and actual MSH would decrease from empty bag to groceries to child conditions. Greater weight, whether physical, social, or moral, is expected to place greater constraints on actions and the perception of action. Second, overall accuracy of perceived MSH relative to actual MSH would be good, as Konczak et al. (1992) observed. Third, if perceived MSH diverged from actual MSH, it would be in a conservative direction, reflecting an increased concern for safety. Some comment regarding the third prediction is warranted.

If one follows the logic of Konczak et al. (1992), increasing the weight to be lifted would heighten safety concerns, encouraging participants to be more careful and thus more accurate in estimating MSH. Extending the logic from physical to moral weight, participants would be most careful, thus most accurate, with their child. This is an appealing line of argument, but there is a clear problem with it. In the MSH task, accuracy does not necessarily contribute to safety; it is far better to err in one direction than the other. Given that concern for safety might increase or decrease accuracy in the MSH task, we expected no difference between perceived MSH and actual MSH for each object carried. If differences occurred, however, they would tend toward underestimates.

Method

Participants and procedure. Participants were the 18 parents from Experiment 1. They were asked to hold their child, an equally weighted bag of groceries,

and an empty grocery bag one at a time; look at an adjustable platform 1 m in front of them; and judge the maximum height that they could climb in a single step. The 0.9 m $\times$ 1.5 m platform consisted of two adjacent aerobic steps, initially set slightly higher than the participant's measured hip height. Participants were told that they would be asked to attempt their estimated MSH while holding the relevant item.

Participants were asked to carry each item identically, as in Experiment 1, and to make their judgments without raising their leg. Using the method of adjustment, experimenters lowered (or raised) the step height 1 (or more) spacers (5 cm each) until participants were satisfied that they had determined their MSH. The order of items carried was the same for perceived and actual MSH and was counterbalanced across all participants.

Participants began their attempts at actual MSH at their perceived MSH for each item. Attempts were made from a standing start at a distance from the platform chosen by participants. After successful attempts, participants repeated the procedure at the next highest level until they were unsuccessful or declined to try. If they were unable to step up to their perceived MSH, the platform was lowered until they were able to do so. Three experimenters served as "spotters" (one beside, one behind, and one in front on the other side of the step) to assist parents if they lost their balance while climbing.

At the completion of the MSH task, all participants answered four brief questions about the task. These questions asked about how difficult and safe the tasks felt, whether it felt different or the same to carry the various objects, and whether various aspects of the tasks (e.g., point lights, being filmed) had puzzled or distracted them.

Results

The mean hip height of the parents was 101.0 cm (range = 86.4–111.8 cm). The mean age and weight of the children were 21 months (range = 3–35 months) and 10.8 kg (range = 5.5–14.5 kg).

Figure 2 compares means for perceived MSH and actual MSH for empty bag, groceries, and child conditions. As predicted, perceived MSH decreased from empty ($M = 74.5$ cm) to groceries ($M = 68.0$ cm) to child ($M = 63.2$ cm) conditions. Actual MSH decreased from empty ($M = 77.3$ cm) to groceries ($M = 70.6$ cm), as predicted, but groceries and child were equal. Using an alpha of .01 for all significance tests, we carried out a 3 (object) $\times$ 2 (predicted/actual) $\times$ 6 (order of carrying) repeated measures ANOVA, which confirmed that there was a large effect for object carried, $F(2, 34) = 52.04$, $p < .001$, $\eta_p^2 = .75$. The divergence of actual and perceived MSH for the child condition resulted in a significant Object $\times$ Perceived/Actual interaction, $F(2, 34) = 5.39$, $p = .009$, $\eta_p^2 = .24$, and was primarily responsible for a significant main effect for perceived versus actual MSH, $F(1, 17) = 14.01$, $p = .002$, $\eta_p^2 = .45$.

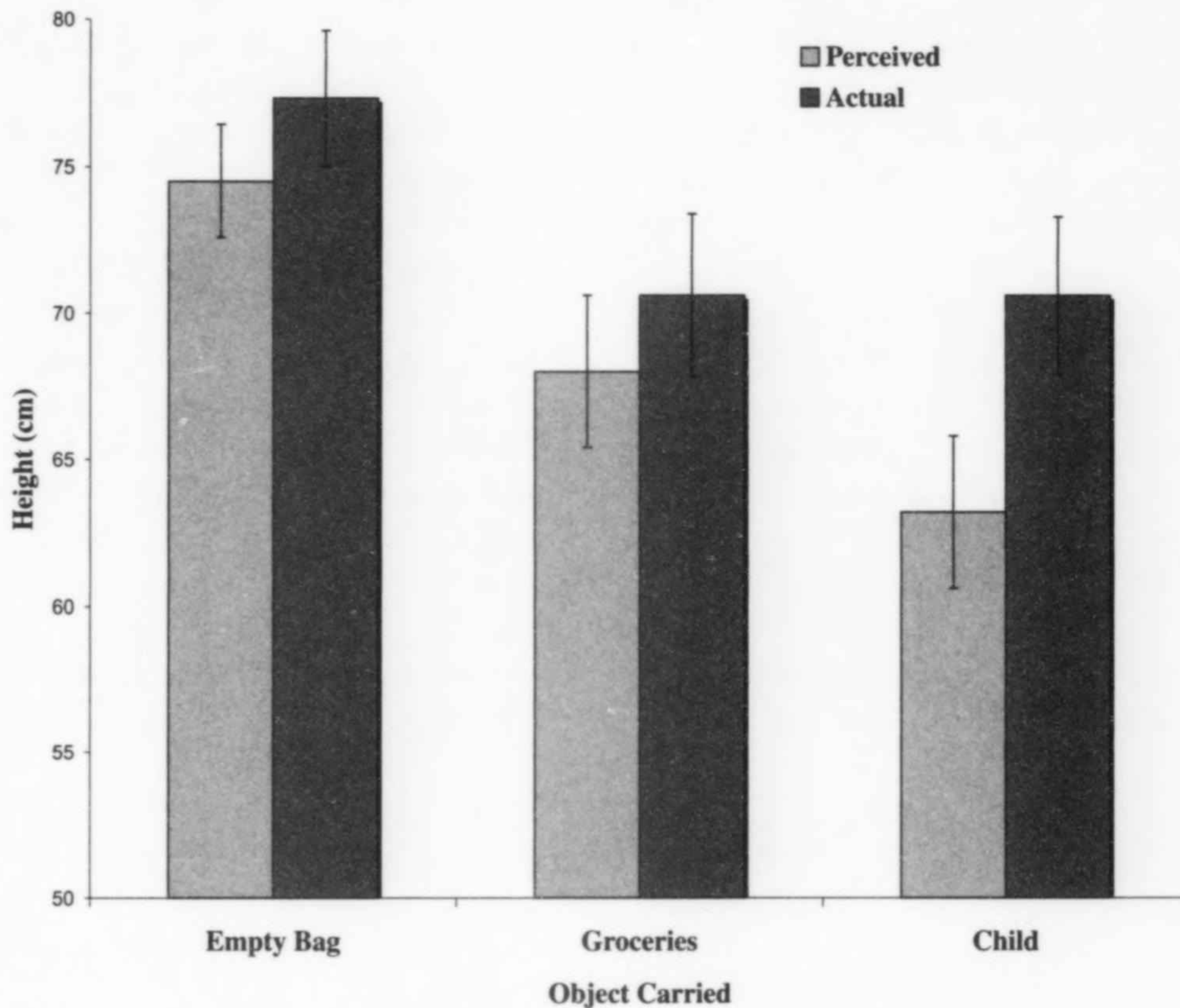


FIGURE 2 Mean perceived and actual maximum stepping heights (+SE) for the empty bag, groceries, and child conditions ($n = 18$) in Experiment 2.

The accuracy of perceived MSH relative to actual MSH was relatively good in the empty bag and grocery conditions (i.e., error was about 60% of the 5 cm depth of a stair spacer, which was the smallest unit of measurement by which the height could be adjusted) but not in the child condition. Paired-sample t tests between perceived and actual MSH for the three conditions were empty bag, $t(17) = 2.75$, $p > .01$; groceries, $t(17) = 1.64$, $p > .01$; and child, $t(17) = 4.18$, $p < .01$. The inaccuracy of perceived MSH for the child condition was, as predicted, in a conservative (i.e., safer) direction.

Unlike Experiment 1, the effect of trials was not significant. This suggests that fatigue did not have a noticeable effect on repeated attempts to determine MSH for each of the three objects.

In their answers to questions asked after they had completed the two tasks, 7 participants (39%) indicated that the task seemed easier with the child or was more difficult with groceries. In addition, 3 mentioned that the groceries felt heavier than their child and 6 said that the child held on or fit their body better than the groceries. On the other hand, 6 parents mentioned that their child moved

more than the groceries, implying that this made the task more difficult. Ten participants (56%) indicated that they were more cautious with their child. In short, parents differed in whether groceries or child was harder to carry, but a majority believed themselves to be more cautious with their child.

Mean pi ratios (MSH to leg length) for actual MSH were .77 for the empty bag condition and .70 for the groceries and child conditions; for perceived MSH they were .74 for empty bag, .67 for groceries, and .63 for child. These ratios are lower than those Warren (1984) and Konczak et al. (1992) found for MSH when nothing is being carried by young people; their ratios were in the .88 to .96 range.² However, the ratios we found are similar to the ratios Konczak et al. found for older people (range = .62-.75). Konczak et al. proposed that pi ratios that are ecologically functional depend on factors in addition to leg length, such as leg strength and hip flexibility. The additional physical weight carried by participants in groceries and child conditions reduced pi ratios, but even maintaining a specific arm posture (per instructions) in the empty condition appears to have done so as well (i.e., relative to Warren's results).

Discussion

As physical weight increased (empty vs. groceries), both perceived MSH and actual MSH decreased. On the other hand, as moral weight increased (groceries vs. child), perceived MSH, but not actual MSH, decreased.

The results indicate that in the MSH task, adding weight, whether physical or moral, does not increase the accuracy of perception regarding action boundaries. On the other hand, it is not clear that it reduces accuracy either. The greater care required to step up with the groceries (which were physically and socially weightier than the empty bag) did not reduce accuracy. However, accuracy was reduced for the child condition; judgment, but not action, was cautious.

One possible reason for this caution is that parents were more aware of the need to be careful when holding their child than when holding groceries. Parents' answers to the questions asked after they completed the MSH task suggest this may have been true for a majority of them. An increased awareness of safety and the obligation to be careful would be likely to shift perceptual judgments in a conservative direction. This increased awareness of safety with one's child may have been diminished in the actual MSH task when parents' attention was focused on coordinating their actions in actual stepping movements.

A second possibility, one we favor, is that parents stepped higher with their children than they expected to because they realized that they and their child were actually safe. This is because they were surrounded by experimenters who were acting as spotters. As parents' attempts to step up approached their maximum height,

²We measured leg length somewhat differently from Warren (1984) and Konczak et al. (1992), so direct comparisons across studies should be interpreted cautiously.

spotters frequently reached in preparation for supporting or lightly touched them in ways that provided no physical assistance (except when they actually lost their balance) but provided reassurance of their protective presence. This "safety net" was not emphasized while parents were making their estimates of MSH (although it was mentioned), and thus would have been less salient than it was during the actual attempts at determining MSH.

A third possibility is that some factor other than increased awareness in judging or reduced concern in stepping up may have differed. Children vary more than groceries in how easy they are to carry. In their postexperimental interviews some parents implied that they perceived their children as more difficult to carry than groceries. It is possible that while they were holding their child and trying to perceive MSH, parents were estimating how cooperative their child would be in the coordinative actions necessary to achieve MSH. Such considerations may have led to lower estimates of MSH.³ Postexperimental interview answers of parents provide some support for this analysis (i.e., 6 noted children moving more than groceries) but also challenge it (i.e., 7 claimed children were easier or groceries were harder to carry).

These results suggest that conscious awareness by itself may not be a reliable indicator of what factors actually constrain actions. When parents were determining perceived MSH they seemed intent on being accurate. Several spontaneously started to raise their leg while holding the bag or child in an attempt to increase their accuracy and had to be reminded not to do so. However, while they were attempting actual MSH, they seemed intent on achieving the highest possible height, even if this was higher than their earlier estimate. Overall, parents appeared to make their judgments focused on accuracy within the constraints of safety, whereas their actions appeared to stress achievement within the constraints of safety.

GENERAL DISCUSSION

We have highlighted two crucial topics that deserve more attention, carrying and caring. It might be argued that carrying is more common than walking without carrying something, yet these activities have attracted remarkably little attention by researchers. Although we take it for granted that people usually care about what they are doing and are careful in its execution much of the time, psychologists have seldom studied the nature of that caring at the scale of individual "behavioral units" (Reed, 1996, p. 31). We suggested that an ecological approach to caring might be framed in terms of values. In particular we considered the role that moral and social value might play in constraining carrying actions, posing the hypothesis

³Our thanks to Sverker Runeson for this suggestion.

that moral and social weight might alter walking movements in ways comparable to the way physical weight does.

Results of two exploratory studies of carrying provide evidence that physical, moral, and, perhaps, social constraints contribute to shaping human movement and perceptual judgment. They support a view of caring as functioning in multiple ways: (a) caring modulates the actions that people attempt and the manner in which those actions are carried out; (b) these modulations of action are perceivable by others; (c) caring constrains self-perception of ability and intention; and (d) caring provides a social background that makes it possible to attempt and achieve certain actions. We elaborate these briefly, noting various issues that need to be addressed.

Caring Modulates Actions

It is important to realize that the perceived modulations of actions that differentiated babies from groceries or trash were gross motor movements, not fine motor movements of hands and arms (but see following) or of facial expression and gaze direction. There are no obvious differences in the postures or walking patterns of the parents carrying items. Nevertheless, our studies indicated that observers judged that those persons who were carrying their children were being more careful. Thus, although we cannot be sure that there is not some conventional heuristic that leads to the differing ratings (e.g., posture, speed of movement), there are no credible candidates of which we are aware.

What physical parameters might differentiate careful actions from those that are less so? This raises a prior question: What are the meanings of *caring* and *careful*? Reed (1982) made the general claim that precision and stability of actions increase as their functional significance increases. Comparable changes in speed, precision, and stability might occur in our stepping task. Marteniuk, MacKenzie, and Jeannerod (1987) reported that the movements involved in grasping a light bulb versus a tennis ball took about the same time overall, but when reaching for a light bulb (which requires more care) the acceleration phase was shorter and the deceleration phase longer. This would suggest that careful walking across uneven terrain might involve rapid, precise push-offs, and slower, damped touch-downs, a possibility we are currently investigating.

Another possibility to consider is whether variations in the elbow light are providing more specific information about the object carried. This fits the impression of some observer participants who indicated that movement of arm and lack of movement of upper body made them wonder if something was being carried. However, their comments do not suggest that this generated much knowledge, if any, of what was being carried. Another difficulty with this possibility is that Schappert's study, reported in Hodges (1999), did not use an elbow light but found a clear difference in perceived carefulness between children and groceries trials.

Caring Constrains Self-Perception and Action

What is the relation between judgment and action relative to values? Both experiments, particularly the second, suggest that conscious judgments and action may not be parallel. Groceries may feel more difficult to carry, but one's footsteps may reveal more care being taken with one's child. One may be aware of protecting one's child when deciding what to do (e.g., whether to attempt a given height in the MSH task), but in the "heat of action" one may do more than one had perceived possible. This suggests that values are not just personal preferences, at least in the sense of conscious desires or attitudes.

In Experiment 2 parents seemed conscious of the obligation to be careful climbing with their child, more so than with groceries, resulting in a more conservative judgment. Other studies have found judgments to be more conservative than actions. For example, Pijpers and Bakker (1995) found that fear of falling affected judgments but not actual reaches in a wall-climbing task. Does this mean that a concern for safety affects judgment but not action? We doubt that this is the case. The point is not that values affect perception but not action; in fact, it is more likely to be the reverse. All values affect action, and in a more balanced, heterarchical way than is sometimes the case in judgment. Perhaps the tendency of consciousness is to fail to realize *all* the values; rather, there is a narrowing or a rank ordering of values (focusing on one or a few to the exclusion of others). Evidence from other studies (e.g., Heft, 1993) indicates that people often overestimate their action-perception skills (e.g., how far they can reach). This suggests that consciousness is not so much conservative as it is inaccurate; it might be risk prone sometimes and cautious at other times depending on whatever value is salient.

An alternative explanation for the observed difference between actual MSH and perceived MSH that we introduced in our earlier discussion of Experiment 2 focuses less on the limitations of consciousness and more on the unforeseen possibilities of social action. One person alone made the judgment about MSH, but that person's actual attempt at MSH was a *joint action* of a group of people all focused on maximizing height and ensuring the well-being of the child and the parent. If this hypothesis is correct, it would suggest that parents would not have stepped as high without spotters. Considering the difference in individual and joint action raises a broader issue to which we turn next—the context of caring that frames what appear to be isolated individuals engaged in simple tasks.

The Effects of a Context of Caring

In one sense, attempting MSH or walking across uneven steps while carrying something is a simple task. However, in another sense, both tasks are challenging ones, involving complex biomechanical coordinations relative to environmental stabilities and variations (Turvey, 1990). The experiments described point to the likelihood that there are social and moral dimensions of those coordinative activities as

well. Tasks such as step climbing are made social just by having experimenters give instructions to participants and by their observation of participants' performances. Thus, the empty condition was socially constrained by virtue of the instruction to hold the bag with both hands while stepping up in a single step onto the platform. The groceries and child conditions were even more strongly constrained socially because the objects being carried had social worth.

Similarly, the two stepping tasks were moral if only because experiments occur in a social context of obligations between experimenter and participants that entail trust, sincerity, kindness, and truth, among other things. But in the child condition certainly, and to some extent in the groceries condition, participants' perceptions and actions were further constrained by moral obligations to the well-being of the child (or to those people who might eat the food).

A number of studies have raised questions about whether social and moral constraints mediate our ability to do what appear to be simple physical tasks. Studies of patients with neurological difficulties have found that participants can carry out physical actions, such as grasping and raising a glass of water to drink, in a natural social situation even though they fail to do equivalent tasks or components of the task in lab tests (e.g., Marcel, 1988). These findings suggest that physical actions are fundamentally and naturally embedded in contexts of caring. Social and moral concerns are not added onto physical actions but are the natural conditions of their occurrence. We suggest that it was just such a context of caring that allowed parents to achieve a higher MSH when carrying their child than they had judged they could safely achieve alone.

Other Issues

Three other issues deserve attention. First, it may be that weight is not the most relevant measure for how items are carried as *physical* objects. Amazeen and Turvey (1996) have presented evidence that what is referred to as *weight* by humans in perception-action tasks may not be physical weight, but *resistance to rotation*, a measure that is affected by volume and shape as well as mass. Thus, postexperimental claims by some parents that groceries felt heavier than their child may not have been misperceptions, but accurate descriptions of differences in resistance to rotation. However, if this were true, it would increase the likelihood that the greater care shown carrying children was not due to physical differences in loads. One possibility for future studies would be to carry children and other objects in some kind of carrier (e.g., a car seat) that makes the physical dynamics more equivalent, although this would be less natural.

Second, social perception research (e.g., Ambady & Rosenthal, 1993) indicates that brief slices of behavior often provide adequate information to form accurate impressions of others. If parents' carefulness in carrying their child can be discerned from observing brief episodes of carrying, are these indicative of their larger, more general patterns of caring?

Finally, would the experience of the observers affect their sensitivity in detecting the care with which actions are done? For example, if parents were used as observers, rather than college students, would carefulness ratings change? If one assumes that parents might be more sensitive observers of the care with which children are carried than college students, then the differences in carefulness we have reported are all the more impressive. However, it may be that detecting the carefulness of others is sufficiently important for humans that specific experiences and concerns are not necessary to achieve accuracy.

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Predicting the Perceived Flow of Time From Qualities of Activity and Depth of Engagement

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Framed in an ecologically grounded and event-based perspective, this study examined perceived temporality during participation in everyday activities for 35 students. Students completed up to 140 experience-sampling surveys rating activity features over 18 days. Structural modeling was used to examine the covariance structures of 8 variables. Differences in speed of perceived time in passing is predicted from 2 variable groups: (a) activity features (novelty, skill, and complexity), and (b) a participation factor (emotional and intellectual engagement, focus on self, and focus on activity). Path coefficients suggest that activity features, along with individuals' skill use, significantly predict the engagement factor, which in turn predicts temporality. A 2-way path between temporality and engagement suggests that increased engagement led to increased perceived speed of time in passing, which in turn increased engagement.

Variations in perceptions of time have been linked to changes in well-being. For instance, time pressure, the sense that time for an activity is scarce, has been associated with stress and diminished physical and mental health (Lehto, 1998; Zuzanek & Mannell, 1998). This perception of a "time crunch" accompanied by high levels of stress is widespread in the U.S. and increasing in Canadian populations (Robinson & Godbey, 1996; Zuzanek & Mannell, 1998). In contrast to a

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perceived time scarcity, a loss of the sense of time has often been associated with positive emotional or optimal states (Csikszentmihalyi, 1988). Because variations in perception of time's passing have been noted as influencing aspects of health and well-being, it is important to understand the contextual and cognitive factors that are related to these temporal variations that emerge in everyday life. Although the examples cited suggest two potential extremes, timelessness and time scarcity, there are other potential alterations in perceived time, such as time slowing or time passing in synchrony with our expectations. The research reported here examines the relation of the qualities of an activity and an individual's engagement in that activity to alterations in the sense of time in passing. This work lays the groundwork for further research examining how different temporal patterns and configurations of these patterns of time in passing are related to variations in health and subjective well-being for individuals.

Although Newtonian conceptions suggest that time is a neutral phenomenon that is linear, regular, and orderly in progression, the temporal phenomena described previously highlight how individuals may sometimes perceive time as fluid during everyday activities. The discordance between lived experience and clock time, dubbed *temporality* (McGrath & Kelly, 1986), recognizes that although we employ schedules and use watches to regulate the organization of our daily routines, the subjective experience that we often call the experience of "time" is irregular. There have been many different approaches to studying perception of time, yet few have successfully accounted for the experiences alluded to here. Even Treisman and colleagues, who support a physiologically based internal clock model of time perception, point out the difficulties of accounting for *subjectively* experienced differences in time's passage in activity: "If one listens to music that is well or poorly played, the time may seem to fly past or to drag, but ... variations in the tempo at which the music is played do not seem to occur" (Treisman & Brogan, 1992, p. 44). Because two senses of "time" yield conflicting results, one cannot be simply dependent on the other.

The premise that time is "real" and can be directly perceived is an assumption ecological psychology challenges. The apparent inconsistencies and contradictions of the body of research examining perception of duration may be viewed as supporting this assertion. For example, studies have noted significant differences in findings regarding time estimates in prospective versus retrospective judgments of time (Block & Zakay, 1997; Grondin, 2001; Hicks, Miller, & Kinsbourne, 1976), which tend to vary depending on the methods of estimation (Block, George, & Reed, 1980; Brown, 1985). Other factors such as the individual's arousal or emotion (Angrilli, Cherubin, Pavese, & Manfredini, 1997; Falk & Bindra, 1954; Loftus, Schooler, Boone, & Kline, 1987); attentional focus (Zakay & Tsal, 1989); task learning (Postman, 1944); motivation or advancement toward a goal (Cohen, 1971; Conti, 2001; Filer & Meals, 1949; Hindle, 1951); and the environmental stimuli present (Glicksohn, 1996; Penton-Voak, Edwards, Percival, & Wearden, 1996; Treisman & Brogan, 1992; Zakay, Nitzan, & Glicksohn, 1983) have also been found to alter duration estimates

in comparison to clock time. Although individuals might not be accurate "clocks," the perceptions of how time passes is a prominent and important cultural phenomenon. The prominence of discussions of the cultural meaning of current child and adult time-use patterns and perception of time, including concern over the loss of ease in schedules and increasing time scarcity, are evidence of this (Hofferth & Sandberg, 2001; Robinson & Godbey, 1996).

Gibson noted that "events are perceived but time is not" (1975, p. 101). The ecologically grounded and event-based perspective of Gibson suggests an alternative to the perceptual and physiological approaches whose aim was to discover "objective," yet abstract, time. The ecological approach provides a framework for examining the experience of time in passing or temporality. Gibson argues that rather than time, what animals experience is the detection of persistence and change in life events within the stream of world events. Block (1992) echoes this, recognizing the importance of the content, order, and spacing of events in estimating time in passing. This event-based approach appears advantageous in examining this phenomenon that appears to be largely subjective, culturally learned, and highly contextual in nature.

Gibson (1975) outlined some essential ideas for understanding perception of time in passing. He theorized that underlying perception of event changes are background patterns or sequences that typically recur over time. Detection of differences between the unfolding of current events against these background events might lead to alterations of the experience of time in passing. For example, changes such as increased novelty or complexity in an activity, or alterations in sequence or nesting of events, could serve as cues for alterations in experiences that are sometimes labeled "time's passing." Other theorists and researchers have suggested similar concepts in the interpretation of time in passing, where individuals compare the current activity against a background of typical expectations. Frankenhauser (1959) proposed that differences in the qualities of the event were gauged via comparison to our expected "average content per unit of duration," and Flaherty (1999) termed this a comparison to the typical "density of experience." These ideas are similar to Gibson's premise. Estimations of typical experience may serve as a comparative gauge for determining how current unfolding events are like or different from typical everyday experiences, therefore creating the perceived degree of change and alterations in time sense.

This being the case, variations in event novelty and complexity could be argued to be important factors in altering perception of time in passing. Events with greater novelty or complexity than would typically occur in a person's routines should influence the subjective experience of time in passing. However, the direction of this alteration—whether time would seem to slow or quicken with greater complexity—is not suggested by these theorists nor completely clear from a reading of current research.

Indeed, research on complexity and duration estimates demonstrate the complicated nature of human estimations of time's passage. For example, Ornstein

(1969) demonstrated that time was retrospectively estimated to be longer for intervals during which increasingly complex content and number of stimuli were processed than for intervals with less complex content or fewer stimuli. By contrast, other researchers noted that when the task difficulty increased, time estimates *decreased* in length and accuracy (Block & Zakay, 1997; Hicks, Miller, Gaes, & Bierman, 1977), contrary to Ornstein's findings. Retrospectively, time estimates increased when individuals processed and remembered more information about the passing interval (Block, 1992; Ornstein, 1969; Underwood & Swain, 1973). Here, the contrast of prospective and retrospective estimates demonstrates *opposite* findings: time apparently speeding by when one was engaged in challenging tasks, but when reflecting back, the task appeared longer. This phenomenon was recognized early, and Sturt (1925) suggested a potential explanation. "The estimates of duration seem to depend on certain divisions of attention, [for] we both experience and reflect on the succession of experiences; and if this division of attention is destroyed, as when we become excitedly immersed in some occupation, we are apt to become oblivious of the passage of time" (p. 89). In other words, the detection of event change in daily life was influenced by cognitive processes such as the direction of attentional focus or deep engagement in the activity.

Sturt (1925) pointed to the importance of the individual's active engagement in the stream of events. One could argue that the number of event changes is detected only by the individual actively attending to them (Hicks et al., 1976). The degree of engagement in a specific activity may be influenced by broad factors, such as personality, and specific factors related to participation in the activity, such as the accompanying emotions, interest in the activity, and skills performing it (Block, 1990). Woodrow (1951), Frankenhauser (1959), and Flaherty (1999) all proposed that temporality emerges from an interpretive process in which the match of the individual's skills and task demands plays an important part. The degree to which certain activities may tax or fail to tax an individual during participation in an activity could alter the magnitude of perceived change in the event or series of events, thereby influencing perceptions of time in passing (Postman, 1944).

The simplest explanation of the relation of event change to time in passing would be that the more event changes detected in circumstances of greater complexity, the more time would be perceived as passing. However, it appears that an examination of the available research suggests the following more complex explanation. Looking back on an experience, an individual may perceive complex or stimulus-rich events as lasting longer compared with typical event patterns. However, during the experience a deep immersion or engagement appears to result in time speeding up or receding from conscious awareness, creating a sense of timelessness. Taken together, the following studies support these proposed relations among event change, engagement, and time in passing. For example, when one is passively engaged, judged time appears to be a function of the number of stimuli present (Block, 1992; Brown, 1985; Brown & Stubbs, 1992; Burnside, 1971; Hicks & Brundige, 1974; Hicks et al., 1977) or what could be described as the magnitude

of event change. By contrast, when processing is required in prospective paradigms, judged time decreased with increased activity or information processing (Hicks et al., 1976; Predebon, 1996).¹ The complexity of stimuli (Grondin, 2001; Zakay et al., 1983); amount of contextual change (Block & Zakay, 1997); task difficulty (Block & Zakay, 1997; Curton & Lordahl, 1974; McClain, 1983); quantity of stimuli (Predebon, 1996); chunking of stimuli (Jones & Boltz, 1989; Poytner, 1989); depth of processing (Arlin, 1986); and learning over trials (Zakay & Tsal, 1989) altered processing load and the perceived duration of the interval (Block & Zakay, 1997; Brown & Stubbs, 1992; Macar, 1996). Processing an increased level of information or greater contextual changes has been shown to be negatively related to subjective duration. It could be argued that active engagement leads to a perception that less time has passed or that the activity has been completed quickly (a temporality in which time appears to pass faster than clock time). The extreme of this circumstance was recognized by Woodrow (1951), who suggested that "situations especially favorable to an experience that is subjectively timeless are those characterized by intensely absorbing occupations, such as reading an interesting novel" (p. 1231).

Besides magnitude of event change and its effect on intensity of engagement, emotion and arousal also appear to influence subjective perceptions of time in passing. Examples of timelessness have been noted in intensely emotional instances of stage performances, high-level athletic feats, and car accidents (Flaherty, 1987). Angrilli et al. (1997) demonstrated that the interaction of positive emotion and arousal was significant and led to underestimates of time's passage. When negative stimuli were present with high arousal, and positive stimuli with low arousal, time was overestimated (Angrilli et al., 1997). These authors suggest two patterns for time estimation alterations: (a) low-arousal attention-driven processes, and (b) high-arousal emotion-driven processes. This suggests that research also needs to attend to the individual's emotional and intellectual involvement in an activity when asked to describe subjective estimates of time's passage.

Flaherty (1999) proposed a process model describing how processing of stimuli and engagement in an activity leads to shifts in perceived temporality. In his theory he explained the dynamics of perceived time in three temporalities: (a) protracted duration (increased perceived time passing compared to clock time); (b) synchronicity (same as clock time); and (c) temporal compression (less time passing compared to clock time). He suggested a U-shaped relation between stimulus com-

¹Hicks et al. (1976) pointed to one of the more knotty difficulties in fathoming this literature. Researchers' reporting of data may confuse the interpretation of findings. Findings have been reported using ratios (estimates:clock time), absolute error (both over- and underestimates), and comparisons of duration estimates in differing conditions to each other without referent to clock time. Depending on how data were reported, this may lead to confusion in discussions. For example, when an activity was described as decreasing the time estimate compared to clock time, this may be interpreted as either an acceleration of time's passage or a lower time estimate. The opposite description has also been used to characterize similar findings.

plexity, or magnitude of event change, and experience of time. He suggested an S-shaped relation between experience of time and information processing. In other words, in conditions of very low and very high stimulus complexity, perceived time is believed to be experienced as protracted or lasting longer than clock time (U shaped). In the middle of this U, synchronicity, a perception of time passing similarly to the clock or in sync with background expectancies, occurs in situations of moderate complexity. In regard to conscious processing of stimuli, he suggested that low levels lead to temporal compression (time in passing shortening), moderate levels lead to synchronicity, and high levels lead to perceived protracted durations. One obvious difficulty with these proposed relations is the absence of compressed time in the conceptualization of stimulus complexity and time perception, and the lack of synthesis of these two conceptualizations. It may be that each level of complexity has its own inverse U curve in which high levels of stress are tolerated easily in easy activities but that same level of stress in a difficult activity is perceived as too much, leading to a performance decrement (Dunham, 1984).

However, Flaherty's (1999) conceptualization of the *processes* through which temporalities unfold provides increased clarity. Considering the individual's skills, abilities, interests, and engagement in activity, Flaherty (1999) proposed a five-step process through which a sense of protracted duration unfolds in daily life. Drawing on narrative data, he suggested that the experience of protracted duration occurs in contexts that are extreme departures from typical events, such as circumstances of violence and threats, suffering or intense emotionality, shock and novelty, concentration and meditation, or altered mental states (Flaherty, 1987). This in turn engages the individual emotionally and then intellectually. Being concerned by the circumstances, the individual is cognitively drawn into the activity to deal with the situation. The emotional response and cognitive engrossment create the depth of engagement in the activity. The depth of engagement then shapes the individual's experience of the task complexity. Being interested in the task, the individual may scan more broadly for more stimuli, and depending on his or her learning and expertise, may interpret these stimuli in more sophisticated ways. For example, the expert chess player sees patterns and a series of possible moves where the novice might only be able to see one potential move. This dynamic of the field of potential stimuli and the engagement with it is person, event, and context dependent. Whether the task is experienced as challenging or complex would depend on the background expectancies or "typical" density of experience the person is accustomed to in activity. This consideration of person-task skill match has often not been considered in examining easy versus difficult processing in temporality research. In fact, many of the "difficult" tasks demanded somewhat more information processing but were not taxing for the participants who performed them. For example, sorting cards into one pile, into two colors, or into suits (Hicks et al., 1976) or identifying words that started with a letter or ended with a letter (Macar, 1996) arguably were not particularly difficult tasks for college students. Thus this dynamic of task-ability match has not been sufficiently explored in regard to temporality.

**THE DYNAMIC OCCUPATION IN TIME (DOiT)
CLUSTER OF VARIABLES AND THE RESEARCH
REPORTED IN THIS ARTICLE**

To extend theory and research to a wider range of temporalities, the first author has introduced the DOiT model. This model includes event and person factors identified as important to temporality. It was devised to explain the dynamic experience of time in passing in everyday activities (Larson, 2004). This model (Figure 1) takes a molar and ecological approach, examining the complexity of temporality within everyday activity contexts. This model is framed in the rhetoric and practice traditions of occupational therapy. The term *occupation* is used as it was historically defined by the profession of occupational therapy and in early psychological research. It describes not only employment but all activities that "occupy" a person's daily rounds (Clark & Larson, 1993). The challenge-ability match and the engagement of individual interests are considered essential features to be considered in understanding human participation and temporality (Larson, 2004).

Subjective sense of time in passing in this model includes a broader continuum of temporalities than previously examined. Using McGrath and Kelly's description of temporality (1986), the lived experience of time in passing is defined in contrast to the common cultural standard of clock time. Although ecological psychology may not view time as directly perceivable, clock time is a pervasive social referent on which individuals reflect in assessing their experience of temporality and so is employed here. In this way "clock time" may actually be a descriptor of an individual's sense of background expectancies for how events typically unfold in combination with references to clocks. Temporalities included in the model are the slowing of time compared to the clock, the synchronicity of time (same as the clock), the speeding of time compared to the clock, and a sense of loss of the perception of time. This sense of timelessness has been termed *flow*; it has been described qualitatively as a merging of attention and action wherein attention to time fades (Csikszentmihalyi, 1988; Csikszentmihalyi & LeFevre, 1989). Temporality is suggested to have a skewed inverted U-shaped relation with event change or information-processing load (a combination of activity complexity and novelty) in which time appears to increase in speed up to a challenging but manageable task-ability demand and thereafter decrease dramatically with time in passing appearing to drag when the load exceeds the individual's capacities.

The DOiT model is a dynamic process model that, like Flaherty's (1993, 1999), suggests that shifts in attention or involvement can alter the perception of time in passing. Beginning with the emotional involvement and intellectual involvement (together called engagement), the depth of focus on the activity or event is shaped in accord with the individual's present interests. For example, habitual activities may require superficial focus, whereas highly novel activities in line with the individual's preferences may create an in-depth focus. Failure to account for shifts in

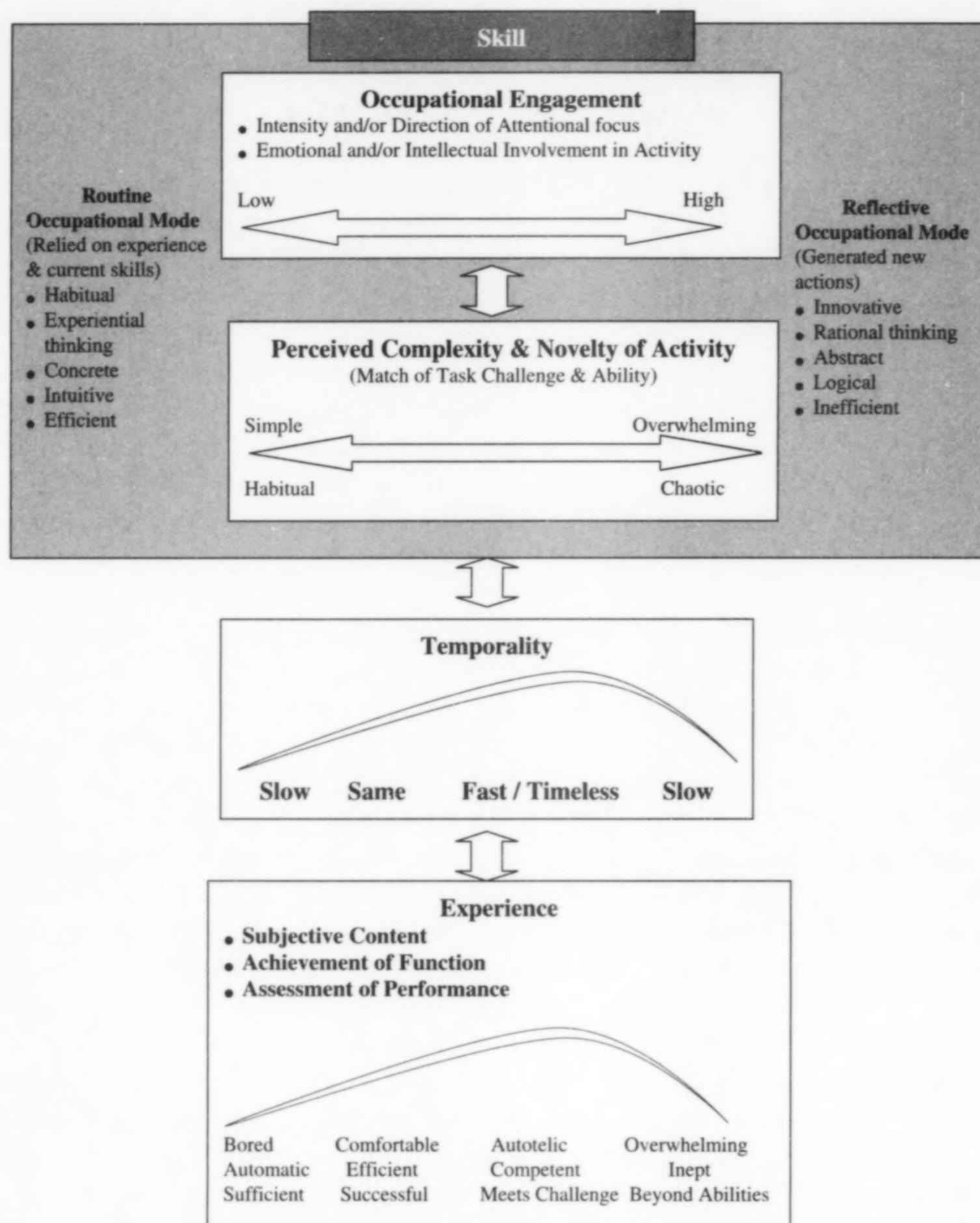


FIGURE 1 Detail of dynamic occupation in time model.

the attention–emotion dynamic may partly explain the previous lack of significant findings in studies examining time estimates and arousal.

The DOiT model considers dynamic person–event changes that may modify perception of time in passing. Increasing engagement either emotionally or intellectually may foster increased activation of arousal, which may have a U-shaped relation to focus on the stimuli or degree of event changes present in the event (Easterbrook, 1959; Flaherty, 1999). The number of event changes and the utiliza-

tion of these cues may vary, thereby influencing perceived temporality through the number and complexity of stimuli processed. In addition, the focusing on relevant cues and the disregarding of irrelevant ones has been suggested to enhance performance (Easterbrook, 1959). High levels of emotional activation, however, may lead to the exclusion of even relevant cues and therefore reduce proficiency.

The resulting focus may also differ in its efficiency and use of available cues depending on the individual's expertise or lack of expertise in the task. The two proposed modes of operation—one that we can rely on easily with regular patterns of behavior that allow us to easily accomplish the task and one that is reflective, requiring more problem solving and unique patterns of behavior—may be more likely used depending on the nature of the task and our ability to perform it. Following Flaherty (1993), the perception of event complexity is proposed to be generated during participation.

This model focuses on in time in passing during the experience. We recognize the differences between time in passing and retrospective assessments. Depending on the novelty and complexity of the task and therefore the person's familiarity in performing it, the activity may be performed skillfully at one extreme or with difficulty at the other, or somewhere in between. Where this challenge–ability match falls on a continuum is proposed to alter the person's perception of their experience and to shift their perception of time's passage. For example, low engagement with low challenge and skill in an everyday event would be expected to lead to less-than-typical density of experience with little event change noted. When the event matches with expectations for typically recurring events, the task draws little attentional focus. Although time in passing appears to move slowly during the experience, the event may be remembered as a low-filled short interval and therefore short in duration. The types of activity that can be performed with such low-level skills are often simple, such as daily care routines that rely on automatic skill sets and evoke little emotion. The opposite is also proposed to be true: High engagement leads to more intense focus, leading to greater complexity in participation, and, if the challenge–ability match is within the person's comfort range, a faster sense of time in passing. Although the event may be remembered as lasting longer than clock time because the interval is well filled in memory, during the experience little, if any, attention is given to clock time because the activity demands the complete attention of the individual. If, however, the challenge–ability match is not within the person's repertoire but stretches his or her abilities beyond reasonable limits, the complexity may be perceived as overwhelming and time may appear to pass slowly. When reflecting back on this event, the memory appears as a large montage of details with no organization, perhaps with a distressing emotional valence. In this case, the event may appear to have lasted a long time. Between these examples, participation in common typical daily tasks, in which skills easily match task demands, temporality is proposed to be perceived as synchronous with clock time, and the density of stimuli, when reflected on, is perceived to be within the

individual's typical range. In this case there may be a more regular correspondence of the experience of time and retrospective sense of time in passing.

This study examines only a portion of the proposed model, specifically, the dynamics of engagement, use of current or innovative skills, event or activity features, and perceived temporality *during* everyday tasks but not other environment influences on these processes except as embedded in the activity. Using an experience-sampling method, an in-the-moment assessment of experience, this study takes a molar and ecological approach to the study of temporality or time in passing. Survey questions addressing the participants' focus on themselves and the activity, their intellectual and emotional engagement in the activity, their perception of the activity's novelty, their skill use, and their sense of time's passage in comparison to clock time were used to examine the core dynamics of the DOiT model.

We hypothesize that occupational engagement (the intensity and direction of attentional focus and emotional or intellectual involvement) interacts with the individual's perceived novelty and complexity of the activity dependent on the individual's skill set, which together interact with the perception of time in passing. Specifically, increasingly intense attentional focus, whether self- or activity-directed, will be related to increased complexity and novelty in activities that require the generation of new actions and skills, which in turn will lead to an increased perceived speed of time's passing. These interactions are conceived of in the DOiT model as bidirectional with increases in one further increasing the other. For example, increased engagement is predicted to lead to a more intense and deeper attention, increasing awareness of the activity's complexity and novelty, which further increases the information processing load and engagement. Likewise, deeply engaging in an increasingly complex and novel task will increase the perceived speed of time compared to the clock and further increase engagement. Although the DOiT model suggests a point whereby novelty and complexity exceeding current abilities leads to a slowing of time, this analysis models the overall relations of this set of variables but not this extreme case.

METHOD

Participants and Procedures

Thirty-five students, 18 to 37 years old ($M = 23.8$ years), who attended occupational therapy education programs in the Midwest and Western United States participated in this study for a period of 18 to 21 days. The majority were women ($n = 34$ women; $n = 1$ man) and White ($n = 29$ White; $n = 6$ Asian). Three waves of data were collected, gathering a total of 2,740 surveys. In each wave of data, participants carried Motorola two-way e-mail pagers throughout waking hours. They were paged randomly 10 times per day, from 7 a.m. to 11 p.m., for cycles of 3 days of data collection and 1 day of rest to recharge the pager. This 4-day cycle was re-

peated until 14 days were collected (140 e-mail pages). Most participants participated for a total of 18 days. Additional days were added when pages were not received due to programming problems or participants being outside paging service areas. This occurred for 3 participants. Participants' individual response rates ranged from 7 to 140 surveys. On average, participants completed 78 surveys of the possible 140 surveys, an overall response rate of 55.7%. Although this appears to be a low percentage, this study collected more surveys on average than the maximum number of surveys (40–70) many other current experience-sampling studies attempted to gather (Barge-Schaapveld, Nicolson, van der Hoop, & De Vries, 1995; Conti, 2001; Klumb & Baltes, 1999). In addition, because this study examined each activity in relation to perceived temporality rather than differences between individuals, this response rate was deemed adequate.

Each time participants were paged, they typed answers to 24 questions and returned the survey via e-mail. The first 6 questions required narrative responses. Respondents were asked questions such as, "Just before you were paged: Describe the main thing you were doing." "What else were you doing?" "Where were you?" "Who were you with (relationship)?" and "How did you *feel* right before you were paged?" The remaining questions required participants to select a response on a Likert-type scale anchored by two extreme adjectives (see Figure 2). These questions were based on the DOiT model and included the following eight variables: the participants' rating of the novelty of the activity (N), their emotional engagement in the task (E), their intellectual engagement in the task (I), the intensity of their focus on the activity (F), their focus on themselves during the activity (Se), the complexity of the activity (C), the reliance on current skill or innovative actions (Sk), and their rating of how time appeared to pass relative to clock time (T). Only those variables currently hypothesized to be related to perceived temporality were included in the structural model.

Analysis and Findings

Data were compiled from e-mail surveys, reformatted, and entered in rectangular format into an SPSS data analysis software program. Ratings of temporality were collapsed from eight categories (seems forever, much slower than clock, slower than clock, same as clock, faster than clock, much faster than clock, lost track of time, and distorted sense of time) into four categories (slower than clock time, same as clock time, faster than clock time, and lost track of time).

The following sections describe a structural model that relates three variable groups to one another. The first group contains three variables that describe three characteristics of activities. The first characteristic is *novelty*, that is, the degree to which a respondent perceived the current activity as novel. The second is *skill*, that is, the amount of skill a respondent thinks was required to complete the current activity. The third variable is *complexity*, that is, the degree to which a respondent

Activity Quality	Survey Question	Rating Scale									
Emotional engagement	How emotionally involved were you in the activity?	0 Not at all	1	2	3	4	5	6	7	8	9 Very Much
Intellectual engagement	How intellectually involved or 'into' the activity were you?	0 Uninvolved	1	2	3	4	5	6	7	8	9 Extremely
Focus	What were you focused on during the activity?	0 Nothing	1 Something else	2 Minimally focused	3	4	5	6	7	8	9 Intensely focused
Self	How focused were you on yourself during the activity?	0 Not at all	1	2	3	4	5	6	7	8	9 Intensely focused on myself
Degree of skill use	How did you accomplish this activity?	0 Relied on experience/current skills	Generated new actions/innovated								
Complexity	How complex was this activity for you?	1 Didn't care	2 Simple	3 Average complexity	4 Just right	5 Slightly complex	6 Somewhat complex	7 Moderately complex	8 Challenging	9 Overwhelming	
Novelty	How would you describe the main thing you were doing?	1 Waiting/Doing nothing	2 Simple	3 Automatic Well-learned	4 Familiar Common Task	5 Slightly complex	6 Somewhat complex	7 Moderately complex	8 Out of the ordinary	9 Disruptive	
Temporality	How did the time pass during this activity relative to clock time?	1 Seems forever	2 Much slower than the clock	3 Slower than clock complexity	4 Same as the clock	5 Faster than the clock	6 Much faster than the clock	7 Lost track of time	8 Distorted Sense of time		
Collapsed Temporality Categories		1 Slower than the clock		2 Same as the clock		3 Faster than clock		4 Lost track of time			

FIGURE 2 Experience-sampling survey questions.

perceives the current activity as complex. In the following paragraphs, we abbreviate this variable group as NOVCOMP.

The second variable group contains four indicators of personal engagement, abbreviated as ENGAGEMENT. The first indicator is *emotional engagement*. This is the degree to which a respondent is emotionally involved in the activity currently participated in. Note that only the degree, not the type of engagement, is rated. Thus, positive and negative emotions are not distinguished. The second indicator is *intellectual engagement*. Here, the respondent describes the degree to which he or she felt intellectually engaged in the current activity. *Focus*, the third indicator, indicates the degree to which a respondent was focused on the activity itself. *Self*, the fourth indicator, reflects the degree of ego involvement or focus on the self when participating in this activity. The third variable group contains as its sole indicator TEMPORALITY. The four categories of this variable describe the speed of a respondent's perception of time while conducting the current activity. As previously stated, eight categories were collapsed to form four categories: (a) a slowing of time in relation to clock time, (b) a perception synchronous or the same as clock time, (c) a speeding up of time in relation to the clock, and (d) losing track of time or inattention to time's passing. Although not truly a continuum of speed of perception, given the fourth category, this is generally a continuum of alteration in the perceived speed of time's passing. Given flow research, the fourth category was deemed important to include.

Using methods of structural modeling, we attempted to predict temporality from the other two variable groups. For all models, we used generalized least squares estimation in LISREL 8.51 (Jöreskog & Sörbom, 1993). We performed the modeling at the level of individual responses. The total number of responses included in the modeling was 2,444.

We started the modeling process with a simple recursive path model in which NOVCOMP predicts ENGAGEMENT, which, in turn, predicts the single-indicator factor TEMPORALITY. This model failed to describe the data well enough, so we modified it in two respects. First, we included a path from TEMPORALITY to ENGAGEMENT. The specified model proposes a reciprocal relationship between ENGAGEMENT and TEMPORALITY. We did not set the two paths between these two factors to be equal, thus providing for the possibility that they differ in strength. Second, we freed four residual correlations.² The final model appears in Figure 3.

The model in Figure 2 describes the data quite well, $\chi^2(10, N = 35) = 17.23$, $p = 0.07$, root mean square error of approximation = .017, standardized root mean square residual = .01, goodness-of-fit index = 1.00, adjusted goodness-of-fit index = 0.99. Figure 2 contains the standardized path coefficients. Each of the coefficients is significant. The only two exceptions are the paths from TEMPORALITY

²Specifically, we freed the residual correlations between variables 1 and 3 ($r = -.21$), 4 and 7 ($r = .27$), 6 and 7 ($r = .09$), and 5 and 8 ($r = -.09$).

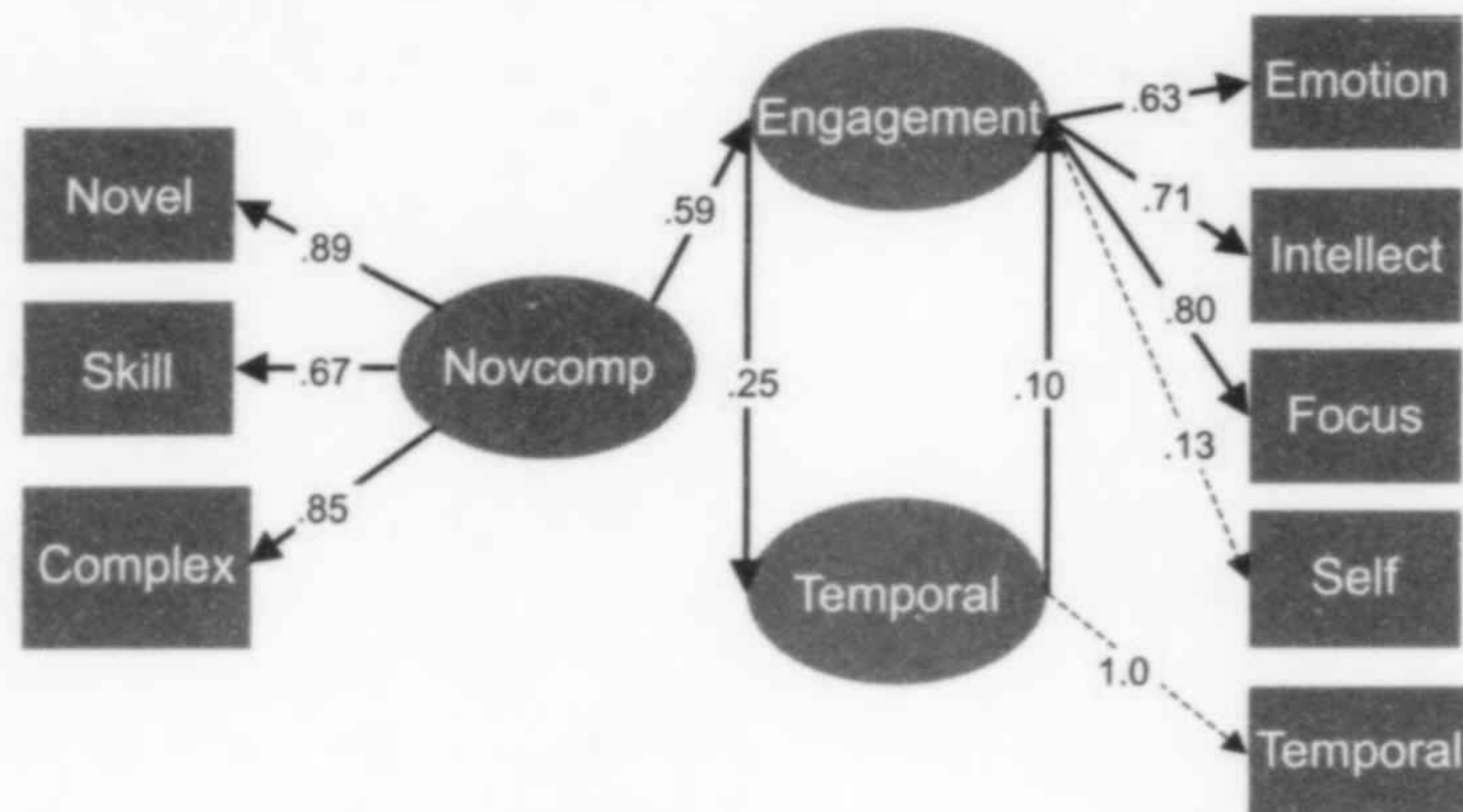


FIGURE 3 Structural model of qualities of activity and engagement as related to temporality.

to its sole indicator and the path from ENGAGEMENT to its first indicator, *emotional engagement*. These paths were fixed.

More specifically, the model suggests that each indicator loads strongly on its respective factor. In addition, there is a significant path from NOVCOMP to ENGAGEMENT. Both paths between ENGAGEMENT and TEMPORALITY are significant. Of these two paths, the one from ENGAGEMENT to TEMPORALITY seems to be stronger than the path from TEMPORALITY to ENGAGEMENT. Specifically, we interpret this reciprocal relationship as a reinforcement loop. When a respondent shows a high level of engagement, time flies. When time flies, the individual engages even more strongly, and vice versa.

DISCUSSION

This research examining the DOiT model took an ecological tack in examining temporality and diverged from previous theoretical models by using an in-the-moment data collection method to examine the perception of time in passing during daily activities. Previous models have been constructed to explain the capacity to estimate durations but not the subjective experience of time during events in daily life. This work, shaped by findings of prior experimental research, contributes to current knowledge by (a) focusing on the subjective sense of time in passing rather than time reckoning of durations in both theory and experimental procedures; (b) examining a combination of factors, including event changes, that influence perceived time in passing; and (c) examining the individual's own interpretation of the activity features that lead to attentional absorption in the task and creating an information-processing load (or level of complexity and difficulty) that may alter perceived temporality.

This study targeted subjective perception rather than prediction of elapsed duration. Although specifically focusing on subjectivity rather than duration esti-

mates adds clarity, another difficulty emerged in this in situ examination of temporality when reconciling these findings with prior findings. It could be argued that participants knew they would be expected to rate their perception of time's passing, a prospective estimate that cued them to attend to time's passing, yet the request for an estimate was immediately following the activity in question, arguably a retrospective estimate. The question that emerges is whether an attentional process, a memory process, or both are utilized in an individual's assessment of subjective temporality. This study cannot answer this question. However, following Gibson (1975), we could argue that these distinctions are not useful; he rejected such divisions of time into past, present, and future and instead described individuals existing in a stream of consciousness of what has, is, and will occur.

In examining the DOiT model, two factors significantly predicted temporality: an activity factor (NOVCOMP) and an ENGAGEMENT factor in which the activity factor affects TEMPORALITY only via ENGAGEMENT. These findings support the importance of considering the interaction of multiple factors in temporality and also suggest that rather than standing alone, the components of the model group together to create three major factors. Novelty and complexity interacted with the individual's skills, clustering within one factor. In the language of some theorists, this is an alteration of the load of information processing. Likewise, ENGAGEMENT included a dynamic interaction of affective and attentional features such as self-rated emotional engagement, intellectual engagement, focus on the activity, and focus on self. Based on this analysis, a reordering of the sequence of factors in the DOiT model is supported, with activity features (novelty, complexity, and skill use) preceding rather than following engagement features. This could be interpreted as the activity leading or drawing the individual's attentional focus and emotional or intellectual involvement. Or this could be conceived as indicating how the current activity is different or unlike everyday experience, the features serving as markers that alert the individual to event change.

Not surprisingly, the paths between TEMPORALITY and ENGAGEMENT were reciprocal, although not necessarily equal in strength, suggesting a dynamic interaction of activity qualities and individual skills and engagement in the activity. In addition, the reciprocal relation between ENGAGEMENT and TEMPORALITY supports the contention that active engagement creates a perceived increase in time's passing and that this increase further facilitates depth of engagement. These findings provide partial support for the dynamics articulated in the DOiT model; they suggest a conceptually even more complex cyclic rather than linear process through which perceived temporality emerges.

CONCLUSION

The DOiT model appears to be a viable initial conceptualization to examine subjective temporality with the revisions suggested by these data. Strong loadings on

NOVCOMP and ENGAGEMENT support the importance of considering these features in predicting the experience of time in passing. This suggests that event change or the comparison of the event with background expectancies in combination with the dynamics of engagement is a good theoretical fit with these data. Engagement in activities appears to be not just a consideration of information load but a combination of both emotional *and* intellectual immersion in the task, as well as the attentional focus to the task and the self. Despite the strong loadings of these factors in predicting temporality, it appears that additional activity or individual dimensions need to be incorporated into the model to better predict shifts in temporality. These additional dimensions may include enjoyment of the activity, satisfaction with performance during the activity, performance stress, approach toward goal attainment, and personality factors.

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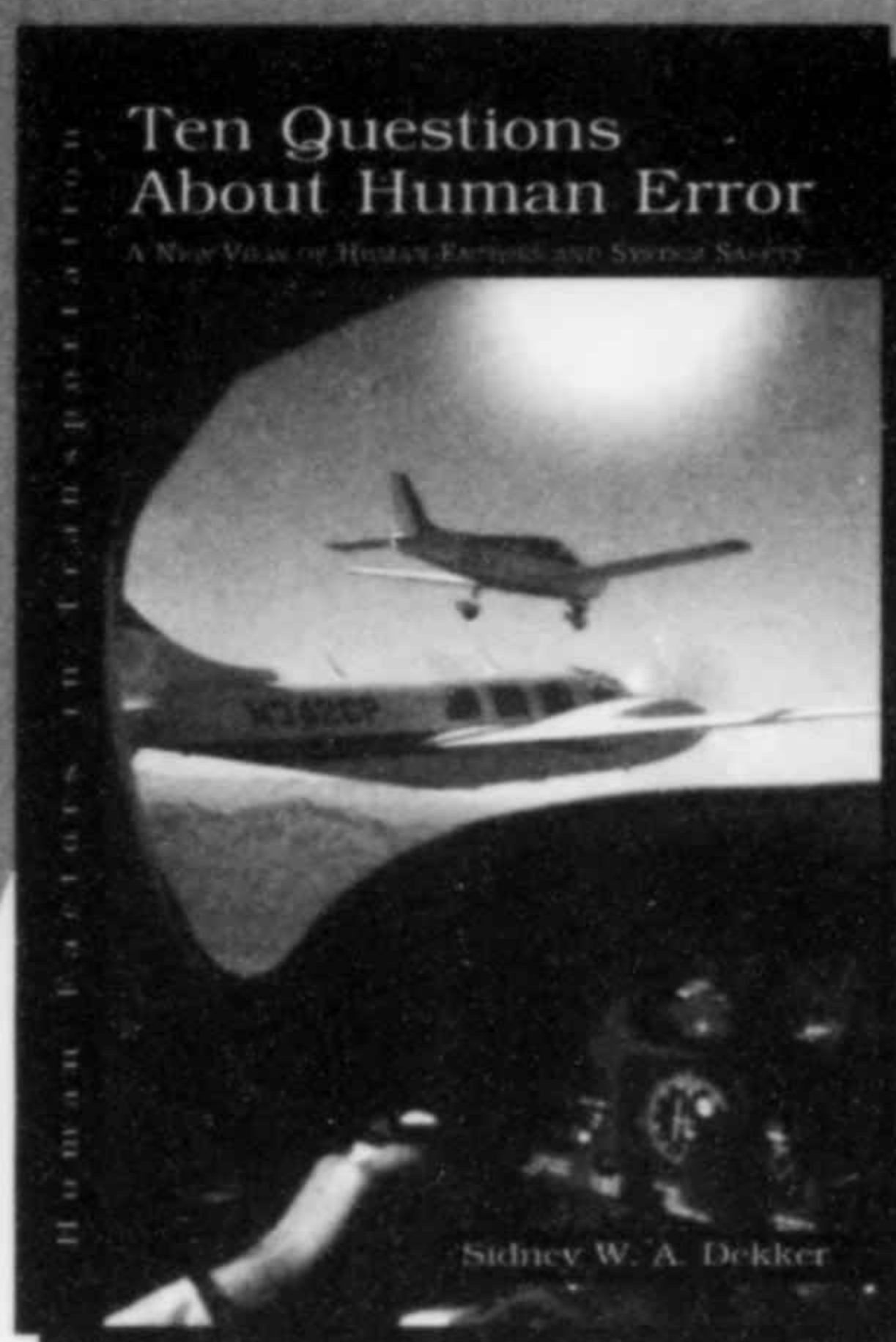
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TEN QUESTIONS ABOUT HUMAN ERROR

A New View of Human Factors and
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SIDNEY W.A. DEKKER

Lund University, Sweden

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Ten Questions About Human Error asks the type of questions frequently posed in incident and

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This volume looks critically at the answers human factors would typically provide and compares/contrasts them with current research insights. Each chapter provides directions for new ideas and models that could perhaps better cope with the complexity of the problems facing human error today. As such, this book can be used as a supplement for a variety of human factors courses.

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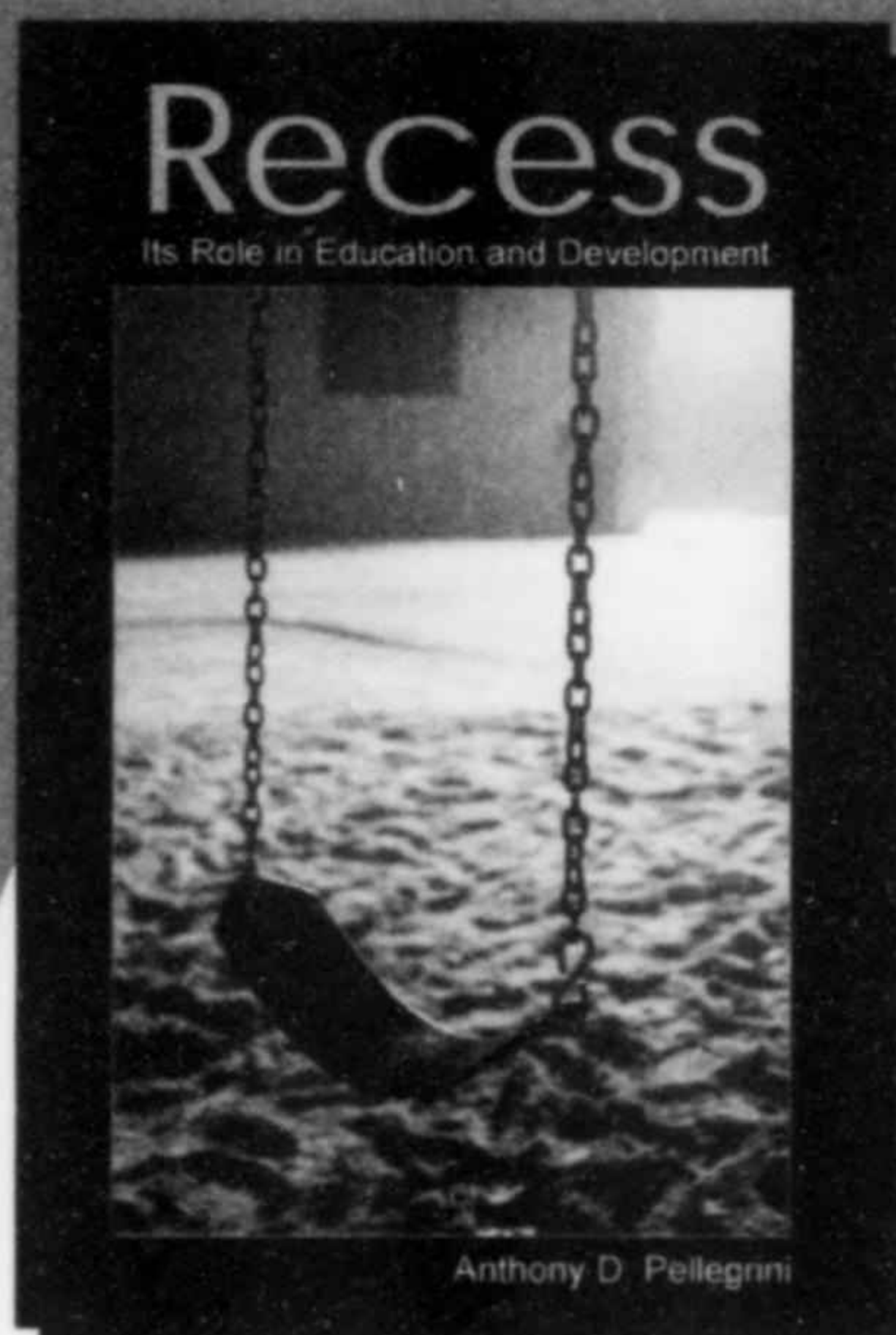
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RECESS

Its Role in Education and Development

ANTHONY D. PELLEGRINI

University of Minnesota

DEVELOPING MIND SERIES

"This is a timely book with an urgent message. School recess is under threat. Pellegrini persuasively argues the case for the need to safeguard recess and play times in schools, on academic as well as social grounds. In the process we also get fascinating accounts of the history of recess, the nature of children's play, and gender differences. This is important reading for school personnel, play workers, and students in education and child development."

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University of London, United Kingdom

Writing a book about recess could be a very questionable endeavor for a serious academic psychologist. At first blush it seems to be a pretty trivial topic. It's the time during the school day where there's a break from what's typically considered the most serious work of the day—reading, writing, and arithmetic. Reflecting this trivial tenor, it's also that time of the school day that kids—perhaps only half jokingly—say is their favorite part of school. This perception has lead many schools to question the role of recess in the school day. This book is an attempt to broach two views of recess—the perceived value of recess and the movement to eliminate or reduce the school recess period from the primary school day.

Due to tightened school budgets and the emphasis on testing, many elementary schools eliminate recess, gym classes, and play periods to the developmental detriment of the very children the schools are supposed to serve. Author Anthony Pellegrini has conducted a number of careful studies regarding student attentiveness and performance within programs that have recess periods, and those that don't. The data show that students need recess in order to blow off energy and interact with each other in the unstructured recess environment in order to grow socially. The goal of *Recess* is to help readers realize the importance of recess and counter the trend to eliminate it from schools.

This book appeals to academics, teachers, administrators, and parents.

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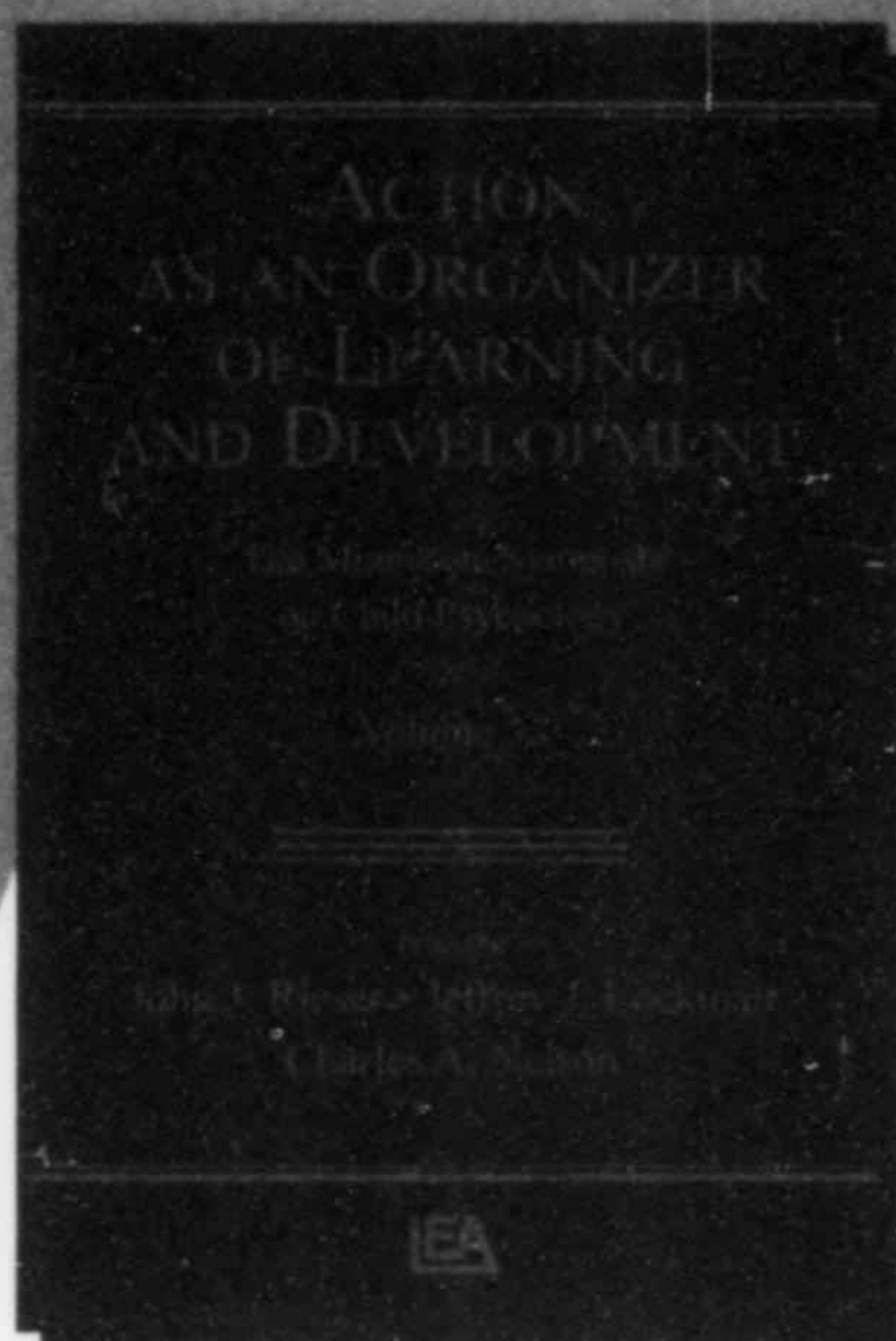
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ACTION AS AN ORGANIZER OF LEARNING AND DEVELOPMENT

Volume 33 in the Minnesota Symposium on Child Psychology Series

Edited by

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Vanderbilt University

JEFFREY J. LOCKMAN

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CHARLES A. NELSON

Harvard Medical School, Boston Children's Hospital

MINNESOTA SYMPOSIA ON CHILD PSYCHOLOGY SERIES

This is the 33rd volume in the Minnesota Symposium on Child Psychology held in October 2002. The symposium was held to honor the scientific and mentoring contributions of Anne Danielson Pick and Herbert L. Pick, Jr.—two longtime and beloved professors of the Institute of Child Development. It focused on "Action as an Organizer of Learning and Development" and integrated the best and most innovative research on the role of action in perceiving and understanding. Taken together, the book captures the intellectual excitement that characterized the 33rd symposium and appeals to developmental psychologists, particularly those interested in perceptual development.

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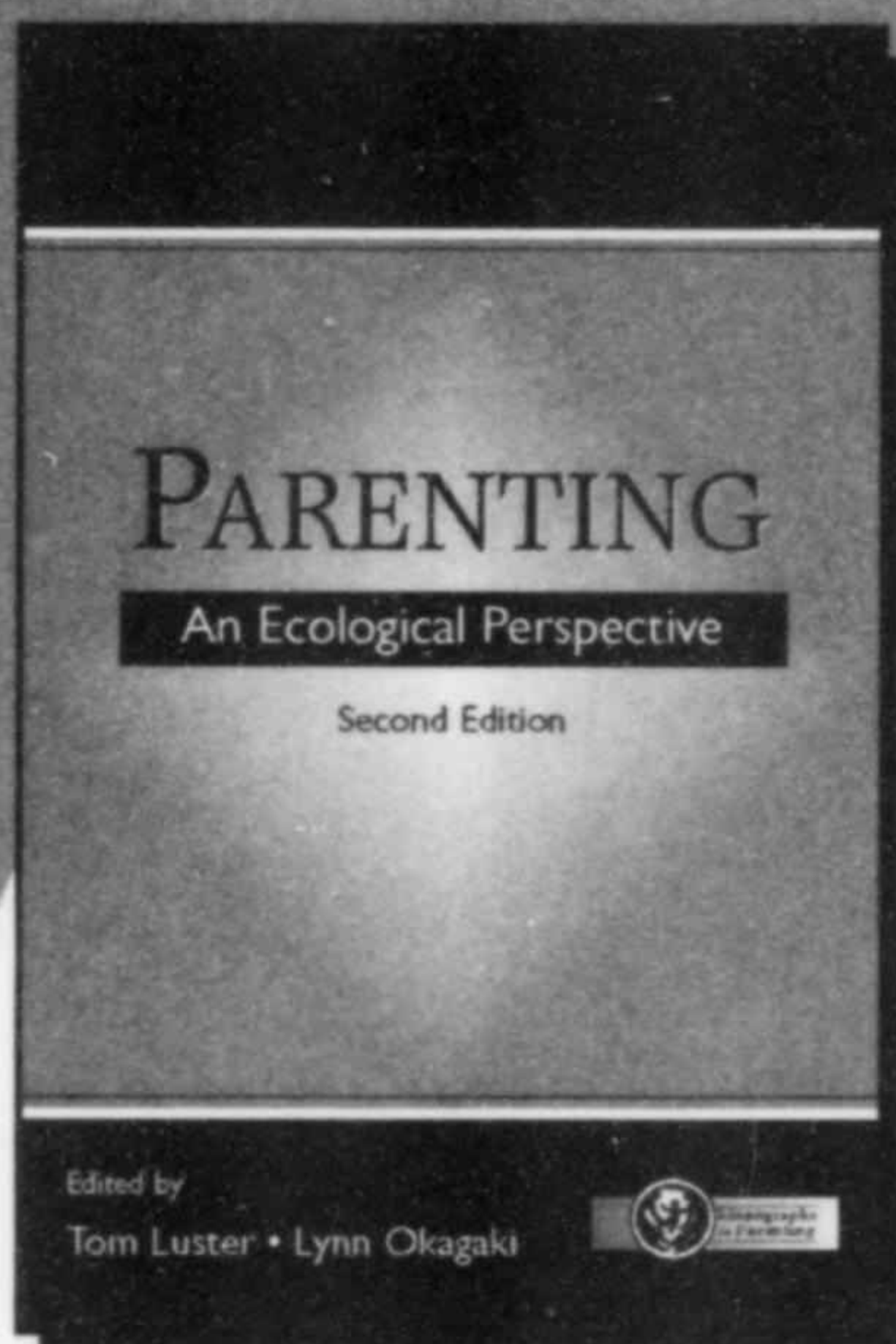
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PARENTING

An Ecological Perspective, Second Edition

Edited by

TOM LUSTER, *Michigan State University*

LYNN OKAGAKI, *Purdue University*

MONOGRAPHS IN PARENTING SERIES

Parenting: An Ecological Perspective was originally created in 1993 to answer questions such as: Why do parents differ markedly in the ways in which they care for their children? What factors contribute to individual differences in parenting behavior? The framework used for addressing these questions is the ecological perspective developed by Urie Bronfenbrenner, who recognized that children's development is influenced by the inter-

actions that they have over time with the people, objects, and symbols in their immediate environment.

Luster and Okagaki have updated the original text focusing on parental behavior and also included 6 new chapters covering topics such as:

- › fathers/gender of parent;
- › children with special needs;
- › ethnicity and socioeconomic status; and
- › parent education.

The text summarizes the latest research on factors that influence parenting, with each chapter providing a look at one important influence and the linkages among these various factors. An ecological perspective draws attention to the fact that the lives of parents and children are intertwined, and that understanding factors that influence parents is important for understanding the experiences of children.

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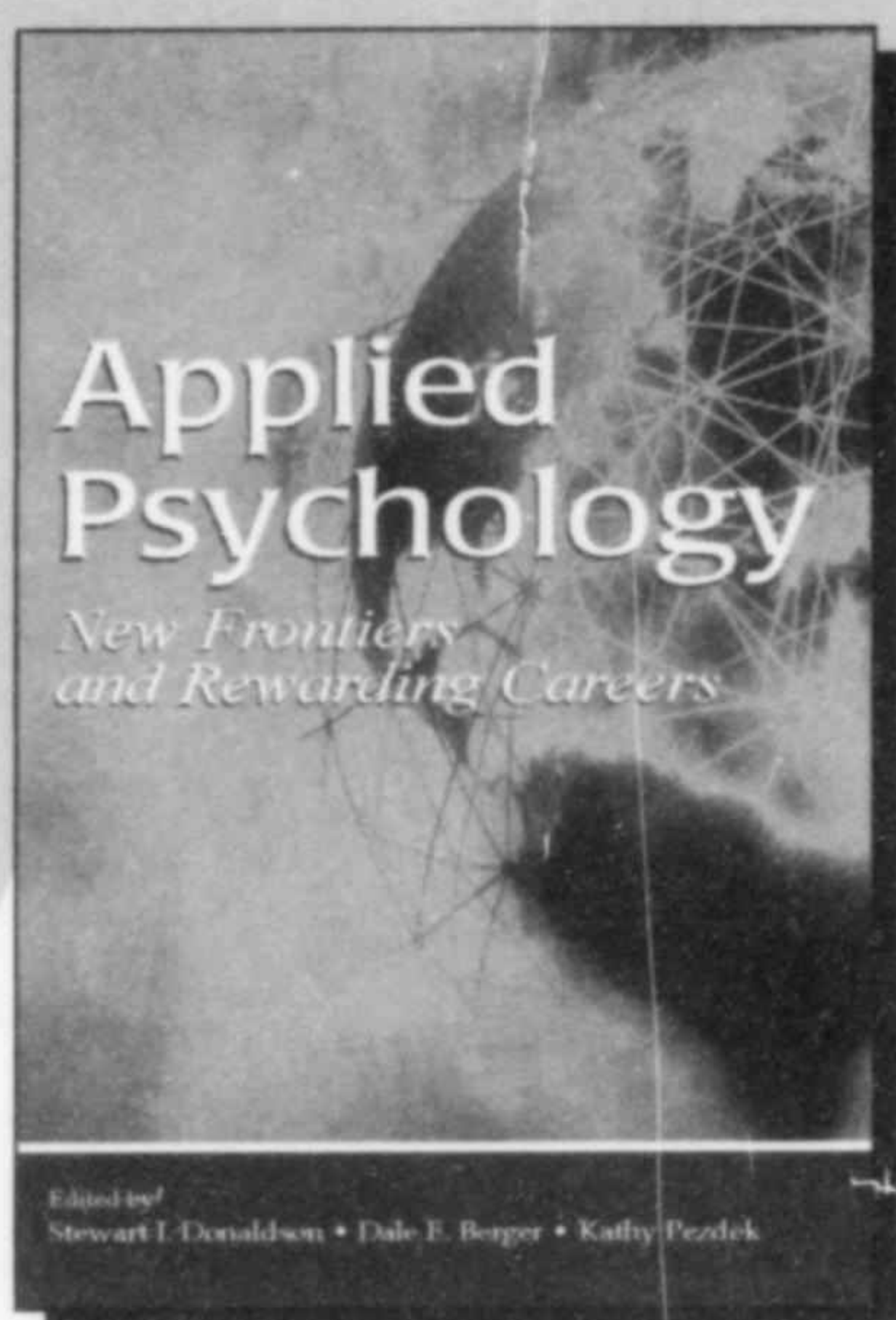
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APPLIED PSYCHOLOGY

New Frontiers and Rewarding Careers

Edited by

STEWART I. DONALDSON,

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Claremont Graduate University

Applied Psychology demonstrates the power of applied psychology to promote human welfare and optimal human functioning as well as the vast career opportunities that exist for those with a psychology education. Some of the most eminent psychologists in the world today examine how psychological science is and can be used to prevent and ameliorate pressing human problems to promote positive social change.

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