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Reflecting on Representation and Process: Children's Understanding of Cognition

SUSAN E. BARRETT
Lehigh University

HERVE ABDI
University of Texas at Dallas
University of Bourgogne at Dijon

JILL M. SNIFFEN
Lehigh University

I. INTRODUCTION

Questions about the nature of representations, the structure of knowledge, and the relationship among perceptual and cognitive processes figure prominently in cognitive theories. These same issues play a central role in the child's evolving understanding of the cognitive system. In this chapter, we will explore preschoolers' and young elementary school children's conceptions of representations and the distinctions they make among various perceptual and cognitive processes. As we review these topics, it will become clear that even three-year-olds are aware of the unique status of mental representations. Young children recognize that they can manipulate representational entities, such as images, simply through mental effort and concentration, but that mental powers are not sufficient for altering physical objects. However, three-year-olds are less clear about the relationship between process and representation. They seem to recognize that some representations are the products of mental processes, such as pretending and imagining, but they find it difficult to reflect on the relationship between supposedly veridical processes, such as perception, and the representations they produce. This latter insight seems to depend on an understanding that perceptual and cognitive processes actively construct and transform information to produce knowledge, and as we will see, young preschoolers do not really appreciate this constructivist aspect of the mind.

An important part of understanding how the mind works involves understanding the distinctions and interrelations that exist among various perceptual and cognitive processes. In this review, we will explore the extent to which children distinguish among these processes and whether children's metacognitive knowledge is organized around these distinctions. As we examine children's conceptions of mental activities, it will become clear that even preschoolers understand that each perceptual system can function independently and that they have at least a rudimentary understanding that perceptual acts can be distinguished from more cognitive activities. Young elementary school children also make some distinctions among cognitive processes and we will consider what these distinctions reveal about how children organize their knowledge about the mind.

A. Chapter Overview

In recent years, developmental psychologists interested in children's ability to reason about intentional behavior and intervening mental processes have posited that even preschoolers possess a "theory of mind." Theories are also

thought to guide conceptual development in other areas. For example, preschoolers have been credited with biological theories and theories about the physical world (see, e.g., Carey, 1985; Keil, 1989). Obviously, this approach to cognitive development raises a number of very important questions. Perhaps the most central of these is what it means to say that knowledge is structured around a theory. In the opening section of the paper, we will explore in some detail the "theory approach" to cognitive development and we will consider why psychologists such as Wellman (1990) believe that it is appropriate to credit young children with a theory of mind.

Two- and three-year-olds' speech is peppered with references to the mental world, and this has sometimes been cited as evidence that the young child possesses a theory of mind. In the second section of this paper, we will examine the mental lexicon to see whether natural language might provide some insight into the child's growing awareness of the mental world. Research on children's use of mental verbs suggests that four-year-olds appreciate that these terms have distinctly mental referents, even though these children do not appropriately discriminate among the mental verbs. As we explain in this section, these findings might suggest that preschoolers find it difficult to distinguish among more central cognitive processes.

Preschoolers could, of course, fail to discriminate among mental verbs even though they understand the distinctions and interrelations that exist among perceptual and cognitive processes. In the third section, we will review some recent studies that focus on whether children distinguish among perceptual processes and how children conceive of the relationship between seeing and knowing. One topic that figures prominently in these discussions concerns the child's conception of representation. We will consider whether young children distinguish between percepts and knowledge-based representations as well as their ability to deal with contradictory representations. This work will be framed in terms of a proposed shift in the child's evolving theory of mind in which a passive copy theory of knowledge gives way to a more active constructivist view (see, e.g., Chandler & Boyes, 1982; Wellman, 1990).

Traditionally, studies of metacognitive knowledge have focused on children's understanding of task and situational factors that affect performance. These studies are important because if children are able to distinguish between relevant and irrelevant situational variables in the context of simple cognitive activities, it would suggest that they are able to reflect on the cognitive processes that are used to accomplish these tasks. In the fourth section, we will review a number of studies designed to uncover what children know about various factors that impede or facilitate performance. A second topic addressed in this section concerns whether the child's metacognitive knowledge is structured around classes of cognitive activities. Adults distinguish among tasks based on the cognitive requirements associated with each. For example, they consider various short-term memory tasks to be similar even when the items that must be held in memory differ dramatically. In this section, we will examine whether children's perceptions of task similarity also vary as a function of the cognitive requirements of the task.

Finally, in the fifth section we will present some of our recent work that focuses on children's understanding of stimulus variables that differentially affect performance. Our findings show that both young elementary school children and older preschoolers evaluate the effects of these variables by reflecting on the specific processing requirements of individual tasks, an accomplishment that we think is made possible by their newfound conception of the mind as an active information processing system.

II. THE ROLE OF THEORIES

A. Scientific and Everyday Theories

Various types of conceptual structures support children's and adults' understanding of the world. A central problem facing researchers in cognitive development involves specifying how these structures are acquired, how they change over time, and the extent to which these structures are knowledge-dependent and domain-specific. Following Carey's (1985) seminal book, an increasing number of developmental psychologists have begun to adopt the theory metaphor as a way to characterize cognitive change. More specifically, researchers working in this tradition have posited parallels between conceptual change in the child and theory change in the history of science. Clearly, there are limits to these parallels and these limits involve both processing and structural considerations.

Consider first the process of theory building in science. Empirical testing, critical reflection, and rigorous theorizing are often considered the very essence of science and yet these are not the processes that characterize the young child's theory building. It is only in pre-adolescence that the child begins to carefully distinguish between theory and evidence and is able to coordinate the two explicitly (Kuhn, 1989). Thus, the process of theory building in the young child is not like scientific theorizing in either the novice or expert practitioner because

the child lacks the metaconceptual skills necessary to reflect on both theory and the process of theory building. But it is also true that even adults and older children who are capable of critical and reflective theorizing rarely do so. Instead, the everyday theories of both child and adult are likely to reflect the same limitations and biases that color knowledge acquisition in general (Kahneman, Slovic & Tversky, 1982; Nisbett & Ross, 1980).

If the young child, and even the adult, lack or at least rarely use the skills most central to the scientific enterprise, what is gained by adopting the theory metaphor? Researchers working in this tradition believe that even though important processing differences exist between scientific and everyday theory building, there may be some important structural similarities that justify the metaphor. In discussing these similarities, Wellman (1990) focuses on an important distinction between framework theories and specific theories that has appeared in the philosophy of science. Wellman believes that the relationship between framework and specific theories in scientific thought parallels the relationship found in intuitive knowledge domains, and that it is this property that adds the most credence to the metaphor. In both scientific and everyday knowledge, framework theories serve three functions. Framework theories define the ontology of the domain, that is, they specify the kinds of entities and processes that are encompassed by the theory and in doing so define theoretical domains. Framework theories are also characterized by their causal-explanatory mechanisms: what counts as a satisfactory explanation differs across theoretical domains. Finally, framework theories constrain process in the sense that they may place limits on the methods that can be used to construct specific theories.

In contrast to framework theories which serve a definitional role, specific theories provide more detailed explanations for particular observations within the confines of the theoretical domain. As Wellman (1990) notes, it is at the level of specific theories that differences between everyday and scientific theories are most striking. In science, specific theories need to be formulated precisely so that they can be subjected to the appropriate empirical tests. Specific everyday theories, on the other hand, do not require such precision. Specific theories, as well as framework theories, are subject to change and revision. Specific everyday and specific scientific theories often change as a result of new observations. These changes, however, do not affect the existing framework theory. When framework theories do change it is typically a product of internal inconsistencies or changes in the scope of the framework theory.

Framework theories house a multitude of conceptual structures in addition to specific theories. Isolated hypotheses and theory fragments are a few examples of the structures housed within scientific framework theories, and scripts, schemas, mental models, associative nets and practical lore are among the variety of conceptual structures that our everyday framework theories encompass (Wellman, 1990). These more specific structures depend to varying degrees on framework theories for their sensibility. For example, explaining why paying for our food is part of the restaurant script involves an explanation that draws on our framework theory of economics, and explaining the courteous behavior of the waiter or waitress would draw on our everyday psychology (see Carey, 1985). It may be the case that certain conceptual structures, e.g., scripts and schemas, are more likely to be informed by multiple framework theories whereas others, e.g., specific theories, may be more closely tied to a single framework theory.

In the present chapter, we will focus on how the child's understanding of the human mind, and in particular, how his or her understanding of specific cognitive processes, changes over time. Following Wellman (1990), we argue that these specific acquisitions are housed under and constrained by the child's framework theory of mind. At the heart of the older preschooler's and adult's theory of mind is a shared commitment to what Wellman has termed a belief-desire psychology. Both the child and the adult predict human behavior on the basis of an actor's needs and desires and the actor's beliefs about how these might be satisfied (cf. Forguson & Gopnik, 1988). Wellman believes that even three-year-olds understand that mental representations or beliefs guide human action although they fail to comprehend the interpretative quality of these representations. Others (e.g., Flavell, 1988; Gopnik & Astington, 1988; Leslie, 1988; Wimmer & Perner, 1983) are not willing to credit children younger than four or four and a half with a representational theory of mind. Both camps, however, believe that only older preschoolers possess an active constructivist view of the mind.

Young preschoolers conceive of the mind as a storehouse of beliefs, images and ideas (Wellman, 1990). They do not focus on the process of knowledge acquisition, but instead focus on the endproducts of processing. Following Chandler and Boyes (1982), a number of investigators (e.g., Flavell, 1988; Pillow, 1988; Taylor, 1988; Wellman, 1990) have proposed that the young child holds a copy theory of knowledge in which the mind passively receives its beliefs from information that is copied or recorded by the senses. This copy theory is not long lasting, however, and soon gives way to an active constructivist view of knowledge acquisition. According to this more mature theory, the mind actively

interprets the perceptual input and uses this information to construct beliefs and ideas which may or may not mirror reality. As the child moves toward an active constructivist view of the mind, he or she begins to focus more on the cognitive processes involved in knowledge acquisition. We believe that this focus on process makes it possible for the child to consider how situational factors might affect processing. In the present chapter, we will examine whether preschoolers and elementary school children recognize that situational factors can differentially affect an assortment of perceptual and cognitive processes. Evidence that children can distinguish the effects of stimulus variables would not only show that they are capable of focusing on process but might also suggest that they hold specific theories that are unique to different cognitive acts.

B. Theories and Conceptual Development

Framework theories constrain, or at least shape, how we acquire and reason about the concepts within each theoretical domain. Wellman (1990) has argued that preschoolers' reasoning about mental phenomenon, as well as their predictions of human behavior, are guided by their framework theory of mind. Two separate but related topics are encompassed by this theory. The first, which is not the focus of this chapter, centers around the child's understanding of intentional behavior. Wellman proposes that two-year-olds understand that people act to fulfill their desires but that at this age the child fails to appreciate that these actions are mediated or "framed" by the individual's beliefs about the world. The acquisition of this insight marks the three-year-old's commitment to a belief-desire framework theory. This framework theory undergoes revision during the preschool period as the child comes to realize that beliefs are not simply copies of the external world but instead are mental representations that are constructed on the basis of the available information which may or may not be sufficient for achieving an accurate representation. A second area subsumed by this framework theory concerns the child's understanding of the nature of mental representations and the processes that construct these representations and our analysis will focus on this topic.

Wellman's (1990) claim that three-year-olds conceive of the mind as a container for mental entities presupposes that children are capable of making some sort of principled distinction between mental and physical entities and, in fact, there is evidence that they can do so. By three years of age, children willingly acknowledge that they can form a mental image of an object and, more importantly, demonstrate some understanding of the special status of these representational entities. When asked to explain why they cannot touch their image of an object or why someone else is not able to see it, three-year-olds typically refer to the image's mental status, for example, by describing it as a thought or in their imagination or alternatively justify their answer by claiming that the image is not real (Wellman & Estes, 1986). In contrast, when asked to explain why they cannot touch an absent object, children's explanations center on the fact that the object is no longer present. An even more compelling finding is that children recognize that mental images are intangible in a different way than physical phenomenon such as shadows or smoke. When asked to explain their inability to touch these later items, children frequently allude to physical constraints whereas mental explanations dominate their discussions of images (Estes, Wellman & Woolley, 1989). Young preschoolers also realize that mental images can be manipulated through mental effort and concentration but that some form of physical contact is needed to transform physical objects. These findings suggest that three-year-olds have at least the beginnings of a representational theory of mind (Wellman, 1990). They recognize that mental entities, such as images and thoughts, are distinct from the things that they represent and that these mental representations have unique properties.

The work done by Wellman and his colleagues makes a compelling case that preschoolers recognize that mental phenomenon constitute a special class of intangible entities that fall within the domain of a framework theory of mind. Presumably, children draw on this theoretical framework to guide their reasoning about mental entities and intentional behavior. We may gain some insight into how the child's theory of mind guides his or her reasoning about mental phenomenon by considering how theories influence conceptual development in other domains. It is now fairly clear that which properties are considered most central to a concept as well as the types of inferences one draws on the basis of category membership depend in part on the encompassing framework theory. This has been shown most clearly in studies that have examined how children generalize properties when category membership is pitted against perceptual similarity (e.g., Carey, 1985; S. Gelman & Markman, 1986). For example, in one study (S. Gelman & Markman, 1986), children were taught that a particular bird feeds its young mashed up food. When later asked to predict how other animals nourish their young, preschoolers credited a very different looking bird with the same feeding habit, but did not predict that a bat that appeared very similar to the first bird would nourish its young this way. Children's willingness to extend biologically important attributes (e.g., feeding habit) across category members, coupled with their tendency to deny that other attributes (e.g., weight) generalize across category members, shows that even preschoolers make theoretically motivated distinctions among properties.

Studies which have looked at how children classify novel objects have revealed a complementary pattern of results (e.g. Keil, 1986, 1989; Mervis, 1987). In Keil's experiments, children were presented with stories about objects that undergo transformations dramatically altering their appearance. For example, in one story, a porcupine was made to look like a cactus. When asked to identify the transformed object, even kindergartners judged that the object was still a porcupine even though it shared more properties with a cactus. These results show that children draw on their framework theory of biology, and more specifically, their belief that natural kinds possess essential properties that cannot be altered by simple transformations, when making difficult decisions about potential category members.

More recently, R. Gelman (1990) and Brown (1990) have posited that one reason knowledge is acquired so rapidly by toddlers and young children is that they are sensitive to the different types of "skeletal causal principles" that structure specific knowledge domains. These principles are thought to constrain how the child filters information from the environment. One example of this is that when learning to pull an object across a table using a stick, children tend to focus on the properties of the stick that have the most functional significance (e.g., its rigidity and length). This tendency to focus on causally relevant properties makes it possible for the child to predict whether other implements can also be used to accomplish this task (Brown, 1990). In much the same way, skeletal properties having to do with locomotion are thought to guide the child in distinguishing between animate and inanimate objects by directing the child's attention to whether or not the object is capable of self-generated movement (R. Gelman, 1990; Massey & R. Gelman, 1988). More generally, it would seem that the child's sensitivity to the skeletal causal principles that structure specific knowledge domains enables the child to place the phenomenon within the appropriate framework theory and to use this theoretical framework to guide his or her thinking. Children's ability to distinguish between animate and inanimate objects and their understanding that desires only guide the behavior of animate beings[1] together with their understanding that mental phenomenon are not subject to the same constraints as physical objects shows that they possess the requisite knowledge to place these phenomenon within their theory of mind. They are then free to draw on this framework as they draw inferences or reason more generally

[1]This is not to deny that at times children borrow from this desire framework to explain the behavior of inanimate objects (cf. Inagaki & Hatano, 1987)

about mental events and intentional behavior.

III. THE MENTAL LEXICON

A. Early References to the Mental World

Part of what holds a theory together is a sense of agreement about what it refers to, and consequently, one function of a theory is to define the ontology of a domain (Carey, 1985). At least by the age of three, children seem to have some grasp of the ontological distinction between mental and physical entities. This suggests that they have separated out certain phenomena as falling within the scope of a theory of mind. What other evidence is there that young preschoolers possess a framework theory of mind? More specifically, is there any evidence that children are aware of the processes that construct these representations? Most children begin to speak about mental states before their third birthday and mental state utterances increase dramatically during the next year (Bretherton & Beeghley, 1982). The child's growing proficiency with the mental lexicon might be taken as evidence that young children are capable of distinguishing between mental processes and external acts or events (but see Piaget, 1929).

There are many problems with using natural language as a measure of the child's growing awareness of the mental world. One problem is that mental terms often serve conversational or "pragmatic" functions. For example, phrases like "I think" are used to soften indirect commands while expressions like "know what" may be used to get the listener's attention. A second, and more challenging, problem is that many mental verbs are correlated with specific behaviors or outcomes in the physical world. For example, "knowing" and "remembering" are almost invariably associated with successfully performing an act, and early studies supported Piaget's claim that preschoolers are unable to distinguish between these mental states and their behavioral correlates (Misciones, Marvin, O'Brien, & Greenberg, 1978; Wellman & Johnson, 1979). But as Johnson and Wellman (1980) note, in these studies the discrepancy between the mental and physical states may not have been sufficiently salient, and as a result, children may have relied more heavily on the readily observable behavioral evidence than they would in other circumstances.

To test this claim, Johnson and Wellman highlighted the discrepancy between the child's belief and the actual event by including a trick condition in

their experiment. Children were instructed to watch as an item was hidden in one of two boxes. Then, after a very brief delay, the child was asked to retrieve the object. On trick trials, the boxes were surreptitiously altered so that the item was not found in the box in which it was hidden; instead it was discovered in the other box. As might be expected, this proved to be a very captivating situation for the child: He or she *knew* where the item should be but performed incorrectly nonetheless. If children simply equate mental verbs with particular outcomes in the physical world, or more specifically, if children believe that verbs such as "know" and "remember" mean that an individual has successfully accomplished something, then in these circumstances children should not claim to know or remember where the item was hidden. But, in fact, they did. Children in the trick condition protested that they knew or remembered where the item was but that the experimenter had tricked them. In short, children's performance under these circumstances demonstrates that they do not simply equate mental terms with behavioral outcomes. Instead, at least by the age of four, children realize that these terms have a distinctly mental referent.

Evidence that even younger children also appreciate this distinction comes from a study by Shatz, Wellman, and Silber (1983) which uses two-year-olds' spontaneous speech to assess their understanding of the mental world. Because the simple occurrence of a mental verb is not sufficient for establishing its reference to a mental state, Shatz et al. used the sentences preceding and following the target utterance as well as the general context of the interaction to guide their interpretation of these expressions. Only utterances which unambiguously referred to the thoughts, memories or knowledge of the speaker, listener or a third person were classified as mental state utterances. This analysis revealed that a sizeable number of children begin to use mental verbs to express mental states in the later part of their third year. What is perhaps an even more compelling finding is that approximately one-fifth of these mental state expressions involved explicit contrasts between reality and mentality, action and intention, or fact and belief. As an example, consider the following comment made by one of their three-year-olds: "Before I *thought* this was a crocodile; now I *know* it's an alligator." Statements such as this provide convincing evidence that the child is not simply equating mental verbs with behavioral events.

B. Mental Verbs

By the end of the fourth year, over 40% of the child's utterances that contain a mental verb are classified as referring to a mental state. But does children's use of these terms indicate that they are capable of distinguishing among cognitive processes? Johnson and Wellman (1980) tackled this question by examining whether or not preschoolers and young elementary school children differentiate the cognitive acts associated with remembering, knowing, and guessing. These acts can be distinguished along a number of dimensions. For example, both knowing and remembering can be used to indicate the presence of knowledge, but guessing cannot. Knowing also contrasts with remembering, however, in that it encompasses a wider range of phenomena. Knowing can be appropriately applied to inferences, deductions, generalizations, and present apprehensions, as well as acts of remembering.

Johnson and Wellman carefully devised a set of situations that would make it possible to evaluate whether children understand the distinctions between knowing, remembering and guessing. Their results revealed an interesting developmental pattern. In Johnson and Wellman's study, preschoolers were willing to say they knew and remembered where an object was hidden even when they had simply guessed correctly. And when the object was "hidden" under a transparent cover, these same four-year-olds claimed to remember where it was although they had not been provided with prior information about its location. Under these conditions, they also reported that they guessed where the object was hidden even though it was sitting in plain sight. So although four-year-olds were able to distinguish between mental and physical states, at least in "trick" situations in which their personal expectations were violated, they did not differentiate among knowing, remembering and guessing. The data from the kindergartners suggests that children begin to make some progress in this area during the next year. Kindergartners seemed to be starting to differentiate among these terms although they clearly lacked a full understanding of these distinctions.

First graders appeared to have a somewhat better grasp of these differences, but it was not until third grade that children had clearly worked out these distinctions. Third graders only claimed to guess in situations where they lacked the relevant information and only reported remembering when they had prior information about the object's location. These children also appreciated the distinction between knowing and remembering. They said they knew where the object was when it was clearly visible and when they could easily infer its location because the alternative location was an empty transparent container. Moreover, these third graders, in contrast with younger children, denied remembering in these situations. These findings suggest that third graders distinguish between cognitive processes that recruit prior knowledge and processes that depend primarily on the currently available information. It is not clear if these children also distinguish between processes that depend on simply reporting prestored information and those that depend on actively manipulating this information to

arrive at an answer. This latter distinction would seem to presuppose a more reflective view of mediating processes.

IV. UNDERSTANDING PERCEPTUALLY-BASED KNOWLEDGE

A. Distinguishing Among Perceptual Acts

Intuitively, perceptual processes such as seeing and hearing, seem more discriminable than cognitive processes, such as memory and problem solving, and there is evidence suggesting that even young preschoolers distinguish among perceptual processes. Young children use the verbs associated with these terms appropriately and typically know which sense organs are paired with these acts. But do children really appreciate that each perceptual system can function independently? If children understand the functional independence of the perceptual systems, they should realize that these systems can be differentially activated. For example, they would be expected to understand that it is possible to hear something without seeing it.

To get at these issues, Yaniv and Shatz (1988) examined whether preschoolers understand that situational variables can sometimes affect one modality but not another. In their study, children were presented with miniature displays and asked whether a small Ernie doll would be able to see or hear a pig or smell or touch some flowers in three different situations. In the *proximity* condition, both Ernie and the target were near each other in the same room. In the *occlusion* condition, Ernie was separated from the stimulus by a single wall, whereas in the *distance* condition, the stimulus was put inside a second open dollhouse seven feet away.

All children recognized that Ernie would be able to perceive the stimulus through all four modalities when it was in the same room. The more important question for us, however, is whether they realized that the occlusion and distance conditions would differentially affect perception. In the occlusion condition, the correct pattern of responses would be that Ernie would continue to hear the stimulus through the barrier but he would not be able to see, smell or touch it. The two older age groups, with mean ages of 45 and 56 months, and half of the 36-month-olds made the appropriate distinctions. When the youngest children erred, they realized Ernie would not be able to touch the object behind the wall, but they mistakenly thought he would continue to see and smell it (cf. Flavell, 1978). In the distance condition, even the youngest children realized it would not be possible to touch the target when it was far away but that it would still be possible to see and hear it. The two older age groups also understood that it would not be possible to smell the distant object.

In sum, it seems that even three-year-olds are quite adept at making judgments about whether or not various conditions permit perception, and they understand that the same factor can make some types of perceptual experiences impossible without affecting others. This may not be surprising. After all, each modality provides a phenomenologically distinct perceptual experience, and children have had numerous opportunities to observe whether or not an object can be apprehended under various occlusion and distance conditions. Moreover, these tasks all involve what Flavell (1978) has termed Level 1 knowledge. The child has only to determine whether or not perception is allowed under these conditions; he or she does not need to understand how percepts might vary under different stimulus conditions or how easily different types of perceptual representations might be constructed in these situations. To answer these latter questions, the child would have to consider how environmental factors might hinder or distort the perceptual process within a single modality.

Given that three-year-olds understand that each perceptual system can be independently activated, it would be interesting to know whether they also understand that because each system constructs its own representation, the resulting percepts may differ. An object may sound like one thing but look like another. For example, consider the container that looks like a cookie jar and sounds like a pig. Novelty items, such as this, that give rise to contradictory percepts should not pose any special problems for the child if he or she understands that each perceptual system constructs a representation on the basis of modality-specific information.

The child's growing awareness of contradictory perceptual representations is one of the topics Flavell and his colleagues (Flavell, Green, & Flavell, 1990) have addressed in their "connections-representations" account of children's early knowledge about the mind. Flavell et al. contend that three-year-olds recognize that individuals can be "cognitively connected" to objects in the external world. These cognitive connections can take the form of seeing, hearing or wanting particular objects, and Flavell et al. present evidence suggesting that even two and a half-year-olds appreciate that their own perceptual connections are independent of one another and independent of other people's.

What three-year-olds fail to appreciate, however, is that auditory and visual events can lead to different, seemingly contradictory, representations of the same object. They do not understand that a toy bear can both *look like* an elephant while wearing a mask and *sound like* a cat when a taped "meow" is played. Flavell et al. argue that this second task is more difficult because it requires understanding that a single object can be seriously or nonplayfully represented in different mutually contradictory ways. The young child is limited, then, because he or she lacks the more sophisticated understanding of mental representation that these tasks require. This concept may be difficult for three-year-olds to grasp because they hold what Wellman (1990) has labeled a copy theory of representation. They expect the visual system to produce a complete and veridical copy of reality. It is likely that this expectation initially extends to all modalities although it is possible that a copy theory is more deeply entrenched in some modalities than others.

If, in the child's view, each perceptual system produces a faithful copy of reality, there is no reason to think that these reality-oriented representations would ever be contradictory. Thus, children's commitment to a copy theory of knowledge may prevent them from considering multiple reality-oriented representations of the same object. It is not surprising, then, that three-year-olds find it difficult to reason about situations in which appearances and reality do not coincide. This limitation is also thought to affect children's performance in tasks (e.g., the false belief task) that require the child to consider two reality-oriented representations simultaneously, one corresponding to a prior state of the world and the other to the current reality (see Flavell, 1988; Gopnik & Astington, 1988; Wellman, 1990). Although children under the age of four or five are unable to distinguish among reality-oriented perceptual representations, we should point out that we know from Wellman and Estes (1986) that they can distinguish among different types of representations. Even three-year-olds draw a distinction between dreams and images on the one hand and reality-oriented representations on the other. What these children fail to appreciate, however, is that reality-oriented perceptual representations can also be distinguished from one another.

B. Distinguishing Between Seeing and Knowing

Three-year-olds recognize that individuals can be "cognitively connected" to the world through their senses and most likely consider these connections to be a source of fairly complete knowledge about at least certain aspects of the world (e.g., the identities of objects that inhabit it). It is even possible that the child's earliest epistemology is based on the premise that seeing or witnessing something is equivalent to knowing it. As Taylor (1988) points out, this does not imply that the child believes that everything that is known must be seen. Instead, it simply means that the child believes everyone who witnesses an event shares the same knowledge.

Chandler and Boyes (1982) have presented a strong version of this argument in which young children are credited with a "copy theory" of knowledge. According to this view, children "believe objects to transmit, in a direct-line-of-sight fashion, faint copies of themselves, which actively assault and impress themselves upon anyone who happens in the path of such 'objective knowledge'" (Chandler & Boyes, 1982, p. 391). Thus it would seem that children who hold a strict copy theory of knowledge should appreciate that perceptual access is required for some types of knowledge.

In general, researchers interested in preschooler's earliest understanding of the connection between seeing and knowing have focused on whether children appreciate the privileged status of someone who witnesses an event. To test this understanding, Pillow (1989) presented young children with a simple task in which only one observer has the opportunity to see an object. In his experiment, a child and puppet were present as a toy dinosaur was hidden in a box. During the hiding action, neither the child nor puppet had the opportunity to see the dinosaur, but after it was hidden, one of them was allowed to peek inside the box. Children were then asked whether they or the puppet had seen the dinosaur and whether either of them knew what color it was. Even the three-year-olds in this study correctly attributed or denied knowledge to themselves or the puppet based on who had looked inside the container. In a second experiment, Pillow found that children recognized that a puppet who simply pushed the box across the table would not know its contents whereas a puppet who peeked inside would (see Pratt & Bryant, 1990, for a similar finding).

In the Pillow study, whoever looked inside the box would know the dinosaur's color. To test whether children distinguish between looking and knowing in this type of situation, it might be interesting to include a condition in which looking does not necessarily lead to knowing. Some less direct evidence that preschoolers do not simply equate seeing and knowing comes from a study by Wimmer, Hogrefe and Perner (1988). In their study, pairs of children played a game in which surprises were hidden in different boxes. In one of their experiments, either one or both children had the opportunity to look inside a box, and then the subject was asked whether his or her partner had seen what was in the box and whether he or she knew what it was. These same questions were also

asked of the child with reference to him- or herself. The four-year-olds in this study correctly reported whether they had seen what was in the box, and if they had looked inside the box, they said they knew its contents. Children also recognized when their partner had looked inside the box but were not willing to say that their partner knew what was in the box. For these children, then, seeing was not sufficient for attributing knowledge to someone else. This might suggest a growing awareness that although beliefs are informed by perception, perception is not always sufficient for knowing. There are, however, a number of reasons for doubting this. First, the objects used in this study were fairly unambiguous (e.g., a coin, a piece of chocolate) and so there is no reason to think that additional information would be needed for identification. Second, the competitive nature of the task may have made some children more inclined to deny knowledge to their partners. And finally, the linguistic complexity of the question may have posed some difficulty (see Pratt & Bryant, 1990), although it is worth noting that the questions about looking and knowing were presented in the same form. At this point, the general conclusion we draw from these studies is that four-year-olds typically appreciate that seeing leads to knowing. The difficulties children experienced in Wimmer et al.'s task are most likely due to specific aspects of the task situation; however, their findings do suggest that children sometimes respond differently to questions about seeing and knowing. This would suggest that children do not simply equate these two activities.

The three studies cited above all involve situations in which the perceptual information is sufficient for knowing. But given our interest in whether children distinguish between perceptual and knowing acts, we may want to explore preschoolers' understanding of situations in which the perceptual information is not sufficient for knowing. In one of the early experiments on this topic, children were given an opportunity to watch (and listen) to a film and were then asked to predict what a viewer would know after watching a silent presentation of the same film. Mossler, Marvin and Greenberg (1976) found that up until about four years of age, children believe that even when their mother watches a film with the volume turned off, she will know about specific events in the film that depend on audio information. Children are thought to err in this situation because they tend to view adults as "all-knowing" figures. (Wimmer et al. (1988) report that a similar finding emerged in their pilot work. When children played the hiding game with a puppet that shared the name of their teacher, they always credited "Monika" with knowing the contents of the box even when she had not looked inside.) The fact that knowledge attribution depends on the age of the perceiver in a way that perceptual attribution does not suggests that children realize that there are differences between seeing and knowing.

Although children may be aware of some distinction between seeing and knowing, Mossler et al.'s work suggests they do not understand how the completeness of the perceptual information affects what can be known in a given situation. In Mossler et al.'s study, the perceptual input was incomplete because the observer was denied auditory input. Studies by Chandler and Helm (1984) and Taylor (1988), which varied the informativeness of the input presented to a single modality, have produced complementary findings. In these tasks, children are first shown a complete picture. For example, they might see a picture of a giraffe sitting beside an elephant. The picture is then covered so that only a small nondescript part is visible. Next the child is asked whether a naive observer would know what is in the picture after seeing only this very restricted view (e.g., only the tip of the elephant's trunk). Both Chandler and Helm (1984) and Taylor (1988) have shown that up until about six years of age, children credit a naive observer with knowing the identity of a pictured object even though the observer has only limited and ambiguous visual input. Once again, this finding would seem to fit with Chandler and Boyes' copy theory--anyone who sees an object should immediately know what it is. But, as Taylor has shown, even four-year-olds recognize that there are limits to what an observer would know based on a restricted view. Older preschoolers recognize that the observer would not know personal information about the depicted animal (e.g., its name or what it likes), and they do not expect the observer to know what the animal is doing (e.g., whether it is sitting or running) even though they themselves know what the animal is doing because they have had the opportunity to view the complete picture. So children are aware that additional information may be necessary for certain types of knowledge, but they believe that the identity of an object is so immediately apparent that it can be gleaned from viewing a small nondescript part.

It should be pointed out, however, that in the Taylor study, children were asked whether an observer would *know* a particular piece of information after viewing the picture. They were not asked to describe what the observer would *see*. If children were asked this question, they probably would not give an objective description of the physical evidence. Rather their descriptions might be expected to reflect what they know about the picture. For example, they might say the observer would see either the giraffe or the giraffe's back when looking at an unidentifiable part of this drawing. Such responses might indicate that the child has difficulty distinguishing between perceptual and knowledge-based representations.

Sodian and Wimmer's (1987) work on children's understanding of inference also suggests that four- and five-year-olds find it difficult to distinguish what a naive observer would conclude based on different pieces of evidence. In their study, an observer had to report the color of a ball that was removed from either a transparent container filled with balls that were all the same color or a transparent container filled with a mixture of different colored balls. Although the observer was always shown which container the ball was taken from, the transfer sometimes took place behind a screen. Four- and five-year-olds were only willing to say that an observer knew the color of the target ball if the observer watched the transfer. They did not recognize that even when the transfer could not be seen, the observer would always know the color of the ball if it was taken from the container filled with identical balls. In contrast, the six-year-olds realized that in this situation, knowledge does not depend on perceiving the entire event but instead can be based on logical inference. This might suggest that children under six do not appreciate that the mind can actively manipulate prior perceptual information to construct new knowledge.

The available evidence, then, suggests that older preschoolers are able to make rudimentary distinctions among perceptual acts and that they do not simply conflate seeing with knowing. But these initial distinctions all seem to involve a type of level 1 knowledge, that is, whether or not a particular object or event can be perceived or known under various conditions. What the preschooler seems to lack is an appreciation of the constructive processes associated with seeing and knowing. Before the child can appreciate that the informativeness of the visual evidence varies as a function of prior knowledge or that people can sometimes infer information about events that they do not directly witness, he or she needs to understand that knowledge is not something that is given out to all who witness an event but instead must be shaped from the available evidence. As these studies make clear, even five- and six-year-olds do not fully understand how the nature of the perceptual input affects this process.

V. REASONING ABOUT COGNITIVE PROCESSES

Three-year-olds conceive of the mind as a repository for mental entities (Wellman, 1990). They recognize that some of these representations correspond to actual objects and events in the world, but, even more importantly, they distinguish between these mental representations and their referents. Three-year-olds also understand that mental verbs, such as knowing and remembering, refer to actual mental states and not the behavioral outcomes they are typically associated with. But despite these impressive accomplishments, there are clearly limits to what the young preschooler knows. In a broad sense, what the young child fails to appreciate is that perceptual and cognitive processes actively manipulate information to construct knowledge. Perhaps this limitation is a function of the young child's tendency to focus on the representations themselves and whether they are "reality-oriented" or "pretend" rather then the processes that produce these representations. Once children come to the important realization that knowledge is not simply given in the world but must be actively created by the mind, they are in a position to consider how various perceptual and cognitive processes contribute to this endeavor.

When adults consider how the mind works, they are likely to think about the different processes that manipulate information to construct knowledge. Within this conception, perceptual processes are distinguished from one another and may also be distinguished from more derived higher-level processing. Adults may even organize their understanding of the cognitive system around different types of processes (Fabricius, Schwanenflugel, Kyllonen, Barclay & Denton, 1989), for example, by distinguishing between classes of activities involving recognition memory and those involving problem solving skills. In the remainder of this paper, we will explore how children's metacognitive knowledge is structured and whether they too distinguish among classes of mental activities. Although young children are able to distinguish among perceptual processes and recognize that there is an important distinction between perceiving and knowing, they still may fail to distinguish among higher-level cognitive processes. Studies on children's use of mental verbs provide some support for this view. Recall that even young elementary school children have difficulty distinguishing between situations that involve remembering prior information and those in which prior knowledge does not play any role. In our analysis, we will focus on whether research on children's understanding of variables that can affect cognitive performance supports this claim that young children are unable to distinguish among cognitive processes.

A. Evaluating Stimulus and Task Variables

Task and situational variables often affect the efficiency of cognitive performance. For example, studying for an exam might be difficult because there is a great deal to memorize or because there is a lot of noise in the dorm. In this section, we will review what preschoolers and elementary school children know about factors that can limit cognitive performance and the extent to which this

work may provide us with some insight into how the child's metacognitive knowledge is structured. In this review, we will explore what children know about global and specific variables. Global variables are those factors that tend to have a similar effect on a variety of cognitive processes whereas specific variables are factors that limit performance in one task but not others. If children do not distinguish among cognitive processes, we might expect that once a child recognizes that a global variable affects performance, he or she will consider it to have a similar effect on all cognitive activities. But even if children prove to have a solid understanding of global variables, it does not mean that they actually consider the processing requirements of particular tasks when evaluating their effects because children do not need to distinguish among cognitive processes to make these predictions. In the latter part of this section, we will explore what children know about factors that have task-specific effects because these judgments require the child to discriminate among the processing requirements of different tasks.

There is now a good deal of evidence that preschoolers and young elementary school children are aware of at least three global variables that can affect performance. For example, four- and five-year-olds understand that background noise can make learning (Miller, 1982) and remembering more difficult (Wellman, 1977; Yussen & Bird, 1979), and that it can hinder their ability to pay attention and communicate (Yussen & Bird, 1979). Young children also understand that the number of items can affect performance. Preschoolers recognize that a longer list is harder to remember (Wellman, 1977) and realize that it is harder to tell a friend about a day filled with many activities (Yussen & Bird, 1979). These children also understand that performance can be hampered by increasing the number of distractors in a visual search task (Miller, 1985) or the number of targets in a monitoring task (Yussen & Bird, 1979). A third factor that children recognize affects performance is motivation. Preschoolers realize that a motivated child is likely to learn more and to remember more items (Miller, 1982; Wellman, Collins & Glieberman, 1981), and kindergartners believe that someone who tries hard will be able to remember even long lists of items even though they recognize that list length may still have some affect on performance (Wellman et al., 1981).

There is also evidence suggesting that once children recognize that a global variable limits performance in one situation, they also appreciate its relevance in other situations. Yussen and Bird (1979) asked children between the ages of four and six how global variables would affect three different cognitive processes: memory, communication, and attention. As expected, even the four-year-olds were aware of the negative effects of list length and distracting noise.

The six-year-olds also recognized that adults usually perform better than children and that severe time constraints can hinder performance. What is especially important about Yussen and Bird's findings, however, is that children's judgments did not vary across these activities. If a child judged that a variable affects one cognitive task, he or she considered it to affect all three. As Yussen and Bird note, this pattern of results suggests "...that children's understanding of cognitive processes may evolve in a system-like or 'synchronous' fashion" (p. 311).

Whereas global variables have similar effects on a variety of cognitive processes, other factors differentially affect performance. If children are able to discriminate among variables that differentially affect cognitive activities, then it would seem appropriate to credit them with at least a rudimentary ability to reflect on the processing requirements associated with different tasks. More specifically, if, for example, children realize that more familiar names are easier to recall but harder to recognize, we would feel fairly confident that they are able to reflect on the different processing requirements of recall and recognition tasks. Before reviewing children's knowledge of specific variables, it may be helpful to point out that all the studies we will be reporting have examined children's understanding of these more specific variables in the context of a single cognitive act. Consequently, it is not clear whether children recognize that these variables are only relevant for certain kinds of activities.

Wellman (1977) has examined young children's understanding of a wide assortment of different memory variables and found that five-year-olds are aware of some specific strategies that can aid recall. These children recognized that it would be beneficial to draw pictures of the items in a memory list and to look at these pictures when asked to recall the items. Some five-year-olds also realized that associated cues could facilitate retrieval, for example, that looking at a leaf could make it easier to remember a picture of a tree (see Gordon and Flavell, 1977; Ritter, 1978; for other examples of what preschoolers know about retrieval cues).

Knowledge of other task-specific variables seems to emerge later. For example, children under nine or ten generally do not realize that a categorized list of items tends to be easier to recall (Moynahan, 1973). Similarly, whereas nine- and eleven-year-olds clearly recognize that pairs of opposites are easier to memorize than random word pairs, six- and seven-year-olds do not (Kreutzer, Leonard & Flavell, 1975). Younger children are not totally unaware of the benefits of organization, however. Moynahan found that seven-year-olds realized that it would be easier to recall a row of colored blocks if the blocks were grouped by color. Young elementary school children are also sensitive to another form of organization: Kreutzer et al. found that 75% of their first graders and all of their third graders thought it would be easier to remember a collection of pictures if they were connected together through a story (Kreutzer et al., 1975).

During the elementary school years, children are becoming aware of a variety of specific variables that influence memory performance. Their facility in making these judgments suggests they have constructed a more specific memory model in which the specific processing requirements associated with different task conditions can be evaluated. Children are also refining their understanding of some of the factors that affect attentional performance. Older children consider both the attentional demands of the task and the nature of the distracting stimuli when making predictions about performance, and they are more adept at judging how stimulus factors such as the separation of targets or the similarity of distractors will affect visual search (Miller, 1985).

B. Classifying Cognitive Activities

Although elementary school children sometimes look very adult-like in their assessment of situational factors that are likely to affect performance, it is not clear that the cognitive requirements of specific activities are especially salient to them. In a recent study (Fabricius et al., 1989), both adults and elementary school children were asked to rate a variety of tasks, such as trying to find the North Star or learning a board game, according to how similar they were in terms of the mental activities each required. Whereas adults, and to some extent ten-year-olds, tended to use the amount of memory each task required as a way of organizing these mental activities, there was no evidence that eight-year-olds distinguished these tasks in terms of the amount of memory each required. A more detailed analysis of the adults' data revealed that four categories of mental activities were distinguished: memory, comprehension, attention, and inference. The memory tasks were further divided into activities that involved list memory and those that involved remembering to do something in the future (i.e., prospective memory). It would seem, then, that the adults relied heavily on the cognitive requirements associated with each task in making their judgments. One implication of these findings is that adults may organize their understanding of mental activities in a way that would make it easy to associate cognitive variables with classes of activities.

Ten-year-olds were also sensitive to the cognitive requirements of these activities, but their judgments revealed that the context in which each task occurred was also considered important. For example, whereas adults subdivided activities according to whether they were primarily memory or comprehension tasks, ten-year-olds tended to organize these same activities according to whether they involved games or learning situations and whether the remembering party's primary responsibility was to adults or friends. Eight-year-olds also tended to rely on contextual features when distinguishing among mental activities. For example, they considered returning a permission slip for a field trip and understanding directions to a friend's house to be highly similar activities, presumably because both are connected with taking a trip. Neither age group evidenced a concept of attention. Instead, these children, especially the younger ones, tended to subdivide activities according to whether they were visual or verbal tasks. This suggests that the perceptual components of these acts were more salient than the more central cognitive components. Again, these findings are important for the present discussion because they suggest that children are capable of distinguishing among mental activities, and that they do so on the basis of whether the activity involves primarily memory or perceptual processing. The distinctions children make, however, are not identical to those made by adults. Children are less likely to recognize a distinct class of attention activities and do not readily distinguish between memory and comprehension tasks. This might suggest that children would have some difficulty sorting cognitive variables that are differentially associated with these classes of cognitive activities. We are currently exploring this topic in our laboratory.

VI. THE INFLUENCE OF TASK-SPECIFIC VARIABLES

In this section, we will explore in more detail children's understanding of specific variables that differentially affect cognitive performance. Our hope is that research on children's understanding of task-specific variables together with studies of children's concepts of mental activities may provide us with some insight into the structure and organization of children's metacognitive knowledge. At this point, we still have only a limited understanding of the distinctions children make among perceptual and cognitive processes. We know that they do seem to make a fairly clear distinction between perceptual and more conceptual processes. They also distinguish among individual perceptual processes, although, at least in the early preschool years, they find it difficult to consider multiple perceptual representations of the same object.

As for how their knowledge of cognitive processes is structured, Fabricius et al.'s work suggests that eight-year-olds do not organize mental activities in the same way as adults. For example, they attach less weight to the memory requirements associated with specific tasks and do not distinguish between

prospective and short-term memory tasks. Instead, they tend to place more weight on the context in which these activities occur. These findings might suggest that young elementary school children would find it difficult to judge how task-specific variables affect different classes of mental activities because these decisions are likely to require the child to focus on both the perceptual and central processing requirements of the tasks rather than the broader context in which they occur. Once the child understands the processing requirements of the task, he or she would then have to evaluate how variations in stimulus conditions or task demands would facilitate or impede processing. In making these judgments, it is likely that the child would not only have to consider in some detail the processes that mediate performance, but he or she might also have to think about the mental representations that guide processing.

A. Experiment 1

In our first experiment, we examined children's understanding of two specific variables, color and size, that would have different effects on the memory and monitoring tasks we chose to focus on. Color is an interesting variable to consider because although it is always present, it does not always have the same effect on performance. For example, typing all words beginning with the letter "a" in red may make them easier to find in the text, but the same red color is likely to be distracting to someone trying to read the paper. An interesting developmental question, then, concerns whether children initially overgeneralize their knowledge of specific variables, for example, by believing that color always improves performance. Evidence that they do so might suggest that they are unable to evaluate the importance of these factors in the context of a specific task.

The memory and monitoring tasks we chose were introduced as jobs at a zoo. In the memory task, the zookeeper was presented with a cage filled with tiny chicken houses and he had to remember which house contained a sick chicken. When the target house was a distinct color, this memory task would be easier. In this first experiment, children judged how changes in the color of the houses and variations in the size of the cage would affect the relative ease of the memory task. As the size of the cage increased, the configuration of houses remained unchanged although the distance between the houses increased. Thus

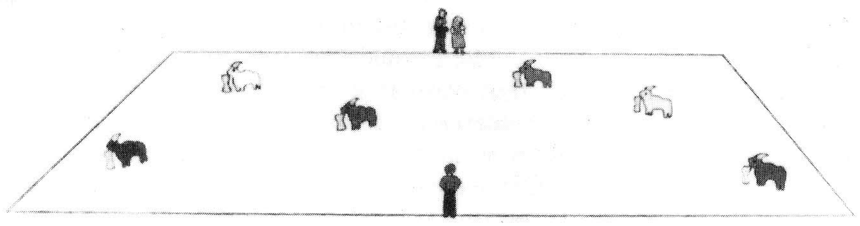

Figure 8.1. A diagram of one of the large cages used in the monitoring task. The figure positioned in the foreground is the zookeeper. The goats in the monitoring task and the houses in the memory task were arranged in this same configuration in all the cages.

there was no reason to think that the demands of the memory task would change as a result of these size variations. When undergraduates were asked to predict how these color and size variations would affect the difficulty of the memory task, they judged that the task would be easier if the houses were different colors but that changes in the size of the cage would not have any effect on the relative difficulty of the task. (The predicted effects of these stimulus changes are summarized in Table 8.1 and an example of one of the cages used in the first experiment is presented in Figure 8.1).

Color and size variations were expected to have a different effect on another one of the zookeeper's jobs. Children were told that the zookeeper also had to watch a small herd of goats and were asked to judge how changes in the color and size of the cage would affect this task. As the size of the cage in-

Table 8.1. Predicted Effects of Color and Size Variations on the Memory and Monitoring Tasks.

	Color		Size	
Task	More Colorful	Less Colorful	Smaller Smaller	Larger Larger
Memory	Easy	Hard	No Effect	No Effect
Monitoring	No Effect	No Effect	Easy	Hard

creased, the goats were farther apart, and adults recognized that this would make it more difficult to monitor the animals. Adults also agreed that variations in the color of the individual goats would not affect this task. To summarize, subjects concurred with our judgment that these color and size variations would have different effects on the memory and monitoring tasks. The memory task would be easier when the houses were different colors, and variations in the size of the cage were not expected to affect memory performance. In contrast, the monitoring task would be easier when the goats were confined to a small cage so the observer would not have to continually scan back and forth across the cage. In this situation, variations in the color of the goats' fur were not expected to affect task difficulty.

Eighteen first graders (mean age: 6-11) judged how color and size variations would affect these two tasks. Model scenes were used to illustrate these variations. The focus of each scene was a rectangular piece of carpet that served as the base of the cage. A zookeeper doll was centered at the front edge of the cage with his back toward the child so that he appeared to be looking inside. The cages for the memory task contained six houses which were positioned so that each one could be seen in its entirety. The same configuration of stimuli was used in all cages. The gray house in which the sick chicken lived was always the third house from the left. Three red arrows were pasted on a small piece of styrofoam positioned above the target house so that the child would know where the sick animal was in each display. For the monitoring condition, six goats were placed inside each cage. The goats were configured like the houses so that each animal afforded an unobstructed view. These scenes were photographed and each scene was presented to the child on a color slide. Each child was asked to make judgments in both the memory and monitoring conditions. The order of the conditions was counterbalanced across subjects. At the start of each condition, the experimenter explained the zookeeper's job and illustrated the possible variations in the size and color composition of the cages. Nine stimulus cages were created by varying the size of the cage and the color composition of the items. There were three levels of the color variable: the animals or houses were all gray, three were gray and three were brown, or each was a different color. Three size variations were possible: the cages were small, medium, or large. Children were then shown pairs of cages and instructed "to point to the one that would make the zookeeper's job easier." Children were also permitted to say that the zookeeper's job would be equally easy in both cages. For each condition, children were shown each of the nine cages paired with the other eight resulting in a total of 36 trials per condition. The left-right position of the cages varied randomly across subjects.

For each of the 36 trials, the child judged if one cage was easier than the other. Each child's preferences were coded as a 72-dimensional vector. To do this, for each trial, we simply designated one stimulus cage *a* and the other *b*. Deciding that *a* is easier than *b* is equivalent to selecting the pair (a,b) and rejecting the pair (b,a). Thus each trial was coded as the child's decision about two pairs. With this convention in mind, the answers of a single child in one condition can be expressed as the pairs which were selected. If the 72 possible pairs are arbitrarily ordered, then the pattern of answers of a child in one condition can be coded as a series of binary values (0,1), where 1 indicates that the pair has been selected, and 0 indicates that the pair has been rejected. If the child declares that the two stimulus cages are equivalent, each pair can be given the value .5.

Correspondence analysis was used to describe children's preferences in the memory and monitoring conditions. A brief digression about correspondence analysis may be useful as the method is not yet well known in the American literature. A more complete treatment can be found in Benzecri (1973, for readers fluent in French) or Greenacre (1984); additional examples can be found in Abdi (1988). Correspondence analysis is used to describe multivariate qualitative data. The data tables are arrays of non-negative elements whose rows represent the characteristics describing the observations. In our analysis, each row represents the answer of a given child in a given condition, and each column represents a pair of stimuli. The aim of the analysis is to display the observations and the characteristics as points on a map. As such, correspondence analysis can be seen as a variety of multidimensional scaling, or as equivalent to principal component analysis for qualitative data. Points that describe similar rows (or columns) are positioned close to each other. Dimensions can be interpreted as in (classical) multidimensional scaling and principal component analysis. The origin of the dimensions is the centroid (i.e., the average vector). In principal component analysis, each axis explains a proportion of the total variance of the data table. In correspondence analysis, each axis explains a proportion of the total chi-square (or inertia) of the data table. An interesting property of correspondence analysis is that it allows the simultaneous display of rows and columns in the same common space (the inertia and the factors extracted are the same for both the set of rows and columns, and each display allows for the reconstruction of the other). The relative clustering of the column vectors provides a measure of the coherence of children's preferences, and an examination of these points revealed that children's judgments were systematically related to the color and size differences in the displays. Although both the row and column vectors were used to define the space and both could be included in

the same display, we have chosen to include only the row vectors in our graphs to facilitate the interpretation of these displays.

One advantage of correspondence analysis is that it enables the researcher to compare the actual data with ideal or theoretical patterns of performance. This advantage is especially important in developmental studies where it is likely that no single child will perform in perfect accord with the ideal. In correspondence analysis, these ideal or theoretical performance patterns can be coded as supplementary rows or columns in the data matrix. These points are not used to compute the analysis. They are projected onto the axes after the solution has been computed for the active rows and columns. The use of supplementary points in correspondence analysis is similar to the use of computing the correlation between an external variable and an axis in multidimensional scaling (i.e., each serves as an aid for interpreting the analysis). To give a more intuitive explanation, supplementary points are located in the places these points would have been if they had been in the data set, but they have no influence on how the analysis is computed. Once these points are projected onto the space defined by the analysis, the spread of data points around these supplementary points can be evaluated.

In the present study, supplementary points were defined to represent "ideal patterns" of responding. For example, one point was coded to represent an "ideal" subject who always picked the most colorful member of each pair and considered cages with the same color composition to be equally difficult. (This is the pattern of responses we would consider correct in the memory condition.) Children's responses were evaluated by examining the extent to which their responses clustered around various "ideal patterns" that were represented by supplementary points. It is important to stress that these supplementary points are not used in computing the correspondence analysis, and accordingly, do not play any role in defining the principal axes.

The results of the correspondence analysis for the first experiment are presented in Figures 8.2 and 8.3. Each point represents a single child's pattern of preferences in either the memory or monitoring condition. The data are presented in the plane defined by the first two dimensions of the analysis. The first principal axis accounted for 35.5% of the total inertia and the second axis accounted for an additional 16.2%. Thus the two-dimensional solution accounts

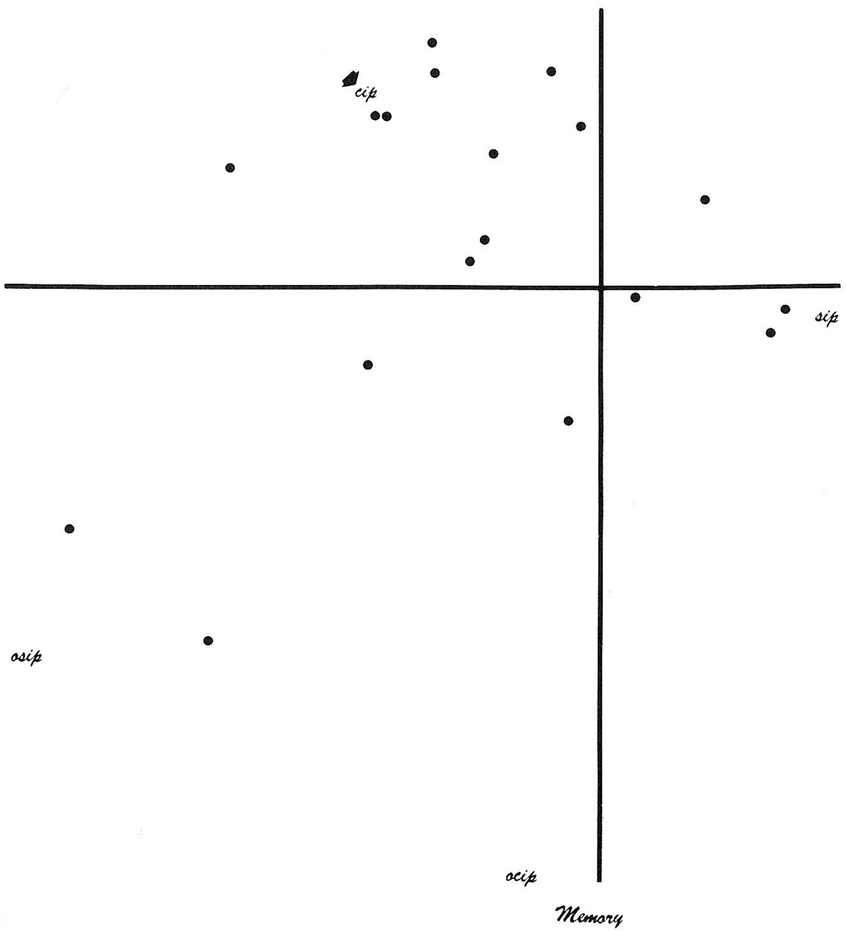

Figure 8.2. The memory data from the first experiment displayed in the plane defined by the first two dimensions of the analysis. The first dimension accounts for 35.5% of the inertia, and the second dimension accounts for 16.2% of the inertia. Children who consistently responded that color variations would facilitate performance would be characterized by the color ideal point, labeled *cip*. Ideal response patterns corresponding to the size ideal point (*sip*), opposite color ideal point (*ocip*), and opposite size ideal point (*osip*) are also included in this graph and subsequent graphs to help anchor the space.

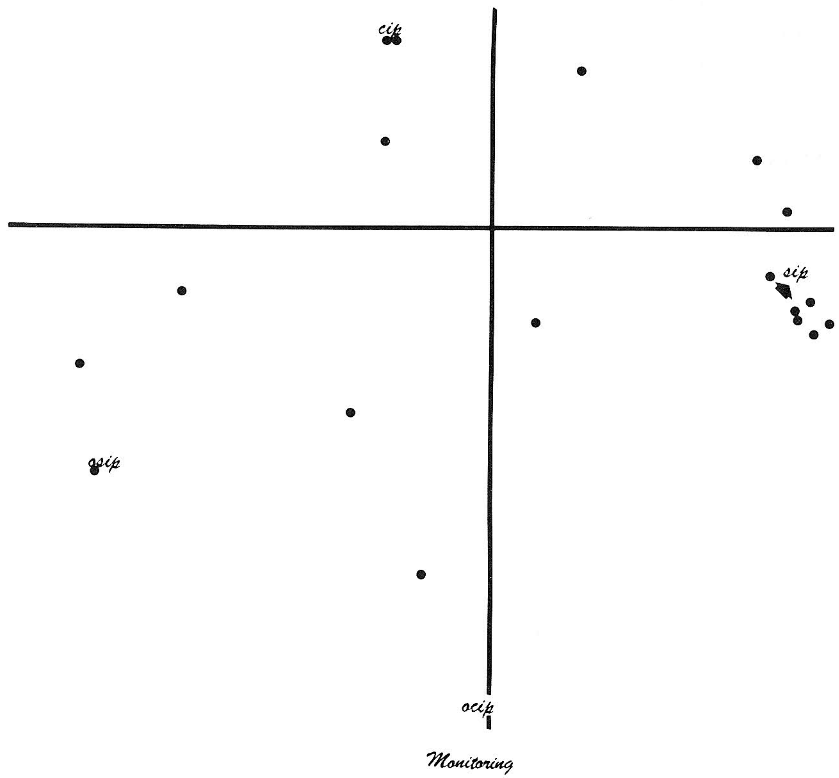

Figure 8.3. The monitoring data from the first experiment displayed in the same two-dimensional space. The first dimension accounts for 35.5% of the total inertia, and the second dimension for 16.2%. Perfect performance is marked by the size ideal point (*sip*).

for 52% of the total inertia (i.e., chi-square).[2] Four "ideal performance patterns" were coded as supplementary points and projected onto the display. Each

[2]It should be noted that because the analyses reported in this paper were performed on "doubled" matrices, the values reported in the text actually underestimate the amount of variability that is accounted for by each axis (see Greenacre, 1984, chapter 5).

performance pattern is "ideal" in the sense that it is perfectly consistent with a specifiable rule. In the color ideal pattern, all decisions were made on the basis of color: more colorful cages were considered easier, and whenever the color composition of both cages was the same, they were considered equivalent. Another ideal pattern was identified on the basis of an opposing rule: in the opposite color ideal pattern, all decisions were made on the basis of color but the less colorful items were preferred. Similarly, two additional ideal patterns were identified in which decisions were based completely on the size of the cage. In the size ideal pattern, the smaller cages were preferred, and in the opposite size ideal pattern, the larger ones were preferred. In both of these ideal patterns, two cages of the same size would be judged to be equally easy.

First consider the data from the memory condition which is presented in Figure 8.2. Slightly over half of the children clustered in the general vicinity of the color ideal point (labeled *CIP*) which suggests that most first graders realize that color can serve as a useful memory cue. A few children gave responses that were scattered around the size ideal point (labeled *SIP*) which means that they erroneously believed that the size manipulation was more important than the color manipulation in this task. But again, it is important to point out that most children recognized that the size manipulations would not affect the ease of the memory task.

Now consider children's judgments in the monitoring condition (see Figure 8.3). Twelve children were tightly clustered around the size ideal point (labeled *SIP*) which indicates that they correctly judged that it would be easier to watch the animals in the small cages. In fact, four children conformed perfectly to this ideal pattern. Moreover, none of the remaining children evidenced a strong preference for the larger cages and only one child considered the color variable relevant for this task. Thus, first graders generally understood that color variations are especially relevant for the memory task whereas size variations are important for the monitoring task.

The general results of this first experiment suggest that children clearly understood that it would be easier to watch the goats in the small cages and that color variations were not relevant for this task. Their judgments in the memory task, however, were less ideal. They seemed to consider both the relevant color and, to a lesser extent, the irrelevant size variations important for this task. The fact that children generally do not consider the size variations equally important for both tasks and their tendency to disregard the color variations when making judgments about the monitoring task, but not the memory task, suggests that first

graders do distinguish between the processing demands of these two tasks. We decided to carry out a second experiment to see if a few minor changes in our stimuli might help children recognize that the size variations were not relevant for the memory task.

B. Experiment 2

In the second experiment, we decided to introduce two changes to see if we could improve performance in the memory condition. First, the houses were painted brighter colors so that the color differences would be more salient. A second change involved the cue that was used to remind the child which house contained the sick animal. Recall that in the first experiment a sign containing three arrows was suspended in the scene. Some children may have mistakenly thought this sign was present in the zoo even though they were explicitly told the contrary. To reduce the likelihood of this, a more artificial cue was used in the second experiment: a large red arrow was drawn directly on the slide. We hypothesized that these changes would produce even cleaner results. We expected to find that first graders' judgments would again be tightly clustered around the size ideal point in the monitoring task, but now we also expected to see a tight cluster of points around the color ideal point in the memory task.

In the first experiment, children performed extremely well in the monitoring condition. We found this somewhat surprising because in pilot work variants of this task often proved difficult. One factor which we thought may have facilitated performance in the first experiment was that the zookeeper was positioned in the scene. In the second experiment, we decided to remove the zookeeper from the display to see if this would have any effect on performance. We hypothesized that if children evaluate the effects of these stimulus variables by mentally simulating the zookeeper's job, their performance might vary as a function of whether or not he is physically present in the scene. We should point out that a family of dolls was positioned at the far edge of the cage in both the first and second experiment so that the child would have a visual guide to the scale of the scene even when the zookeeper was absent.

Eighteen first graders (mean age: 6-9) took part in the second experiment. The slides for the monitoring conditioning were exactly the same as those used in the first experiment except that the zookeeper was not photographed in the scene. The stimuli for the memory task also resembled what was used in the first experiment except that both the zookeeper and the sign were removed from the scene, and the houses were painted more distinct colors. After

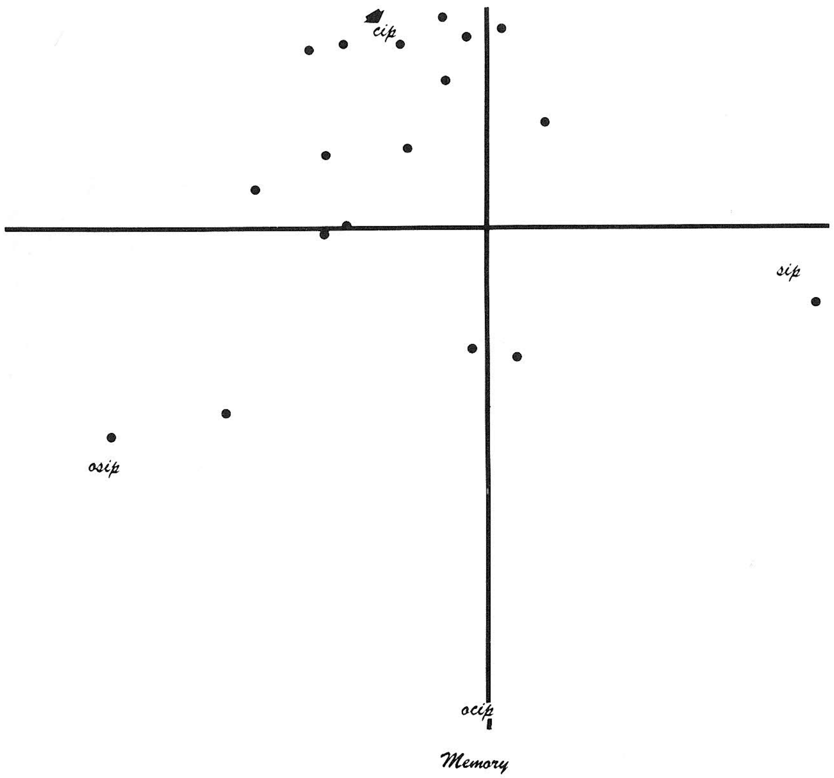

Figure 8.4. The memory data from Experiment 2 presented in the two-dimensional subspace defined by the analysis. The first dimension accounts for 36.6% of the inertia, and the second dimension accounts for an additional 16.6%. Points near the *cip* point represent children who realized that color variations would affect memory performance wheras changes in the size of the cage would not affect performance.

the houses were photographed, a large red arrow was drawn on each slide so that it pointed to the target house. The procedure was identical to that used in the first experiment.

A correspondence analysis was performed on the data from the second experiment. The first axis accounted for 36.7% of the total inertia and the second axis accounted for an additional 16.6%. Thus the 2-dimensional solution accounts

for 53% of the total inertia. The results of the correspondence analysis are presented in Figures 8.4 and 8.5 along with supplementary points. The data from the memory condition, which are displayed in Figure 8.4, resembled the results of the first experiment: Children generally believed that the more colorful cages would facilitate memory, but their judgments were not tightly clustered around the color ideal point (labeled *CIP*). As can be seen in Figure 8.5, children's performance in the monitoring task also fell somewhat short of the ideal. Although half of the first graders were in the vicinity of the size ideal point (labeled *SIP*), the remainder were fairly spread out. It would seem, then, that first graders' performance is attenuated when the zookeeper is not present in the scene. The fact that this simple manipulation affects performance suggests that first grade may be a transitional period for this task. These children are able to judge how size variations will affect performance when the zookeeper is present in the scene to anchor the scale change but these judgments become more difficult when the zookeeper is not included in the scene. Along these lines, it is interesting to consider the relative positions of the outliers. In the first experiment, the zookeeper was depicted in the scene, and no child thought that it would be easier to watch the goats in the large cages. In the second experiment, however, a few children gave responses that were generally consistent with this opposite size ideal pattern (labeled *OSIP* in the figure). So when the zookeeper was not included in the scene, some children erroneously believed it would be easier to monitor the animals in the larger cages. It is possible that such judgments reflect an egocentric bias: Children may have based their judgments on how crowded the array appeared to them without considering the scale change.

The results of these two experiments suggest that first graders appreciate that remembering and monitoring are decidedly different cognitive activities. Children recognized that color variations would affect memory performance but that size variations would be unlikely to have much of an effect. In contrast, the size of the visual field was judged to be an important factor in the monitoring task, whereas color variations among the stimuli were considered to be of little importance. It seems that young school age children are able to evaluate the effects of stimulus factors in the context of particular cognitive acts. Even the way in which children arrived at their decisions suggests that they were not inclined to overgeneralize the effects of specific variables. In the memory task, many first graders appeared to understand immediately that it is easier to remember an item when it is a distinct color; they may even have had a general rule linking the distinctiveness of the target with improved memory performance. Although children's judgments diverged somewhat from the ideal, this may not be all that surprising given that in many pairs the target was not a distinct color. In pilot

Figure 8.5. The monitoring data from Experiment 2 graphed in the same two-dimensional subspace. The inertia accounted for by the first dimension is 36.6% and the inertia accounted for by the second dimension is 16.6%. Here children who fall in close proximity to the *sip* performed optimally in the task.

work, we found that older children and adults tended to use a probability-based rule in these situations, judging the memory task to be easier when there were fewer items the same color as the target. That is, they thought the memory task would be easier if one of three gray houses was the target rather than one of six

gray houses. First graders may have been less likely to consider this factor in their judgments.

Children have probably had numerous opportunities to observe how the distinctiveness of a target affects memory performance. In contrast, the attention task they were presented with in the monitoring condition was somewhat unusual, and it is unlikely that first graders possess a general rule linking monitoring ease with the size of the visual field. We suspect that when asked to make decisions about this task, children may have attempted to mentally simulate the zookeeper's activities. Including the zookeeper in the display probably facilitated such enactments and helped children understand how size would affect performance. Through these simulations, children may have come to realize that the zookeeper would have to rotate his head farther when watching the animals in the larger cages. At the end of the experiment, when asked how they decided where the zookeeper's job would be easier, some children commented that the zookeeper would have to turn his head back and forth when watching the goats in the big cages. (Many children even demonstrated this action as they gave their explanations.) A few first graders, however, commented that the larger cages would be more difficult because the distant animals would be harder to see. These children may have based their decisions on the general rule that an observer who is closer to an object will see it better (see Flavell, Flavell, Green & Wilcox, 1980).

The results of these first two experiments suggest that by the end of first grade, children are aware of many variables that affect cognitive performance and that they are able to evaluate the effects of specific variables with reference to particular cognitive activities. Some of the studies that we reviewed earlier (e.g., Miller, 1982; Wellman, 1977; Yussen & Bird, 1979) suggest that preschoolers are also aware of a variety of factors that can influence performance, but it is not clear if they too can evaluate the effects of stimulus variables in the context of specific activities. Our third experiment was designed to address this issue.

C. Experiment 3

In the third experiment, we asked preschoolers to judge how changing the number of items would affect mental and physical activities. We selected two tasks that had a strong motor component and two that were more cognitive in nature because we wanted to see if children first work out the effects of number variations in the context of physical activities. One reason we suspected this might be true is that motor tasks often provide direct feedback about how task manipu-

Table 8.2. Predicted Effects of Number Variations in Experiment 3.

		Number of Items	
	Task	3	12
Topple			
	Memory	Easy	Hard
	Tipping	Hard	Easy
Doors			
	Hiding	Hard	Easy
	Opening	Easy	Hard

lations affect performance. It is interesting to note in this context Markman's finding that five-year-olds can predict their performance in certain motor tasks more accurately than they can predict the amount of information they can recall (cited in Flavell & Wellman, 1977).

We chose number as the relevant variable in this experiment because differences in number are likely to be salient to young children (R. Gelman & Gallistel, 1978) and because number is likely to be one of the first stimulus factors that children recognize has an effect on performance (Wellman, 1985). In many situations, tasks become more difficult as the number of items increases. For example, a longer shopping list is harder to remember, and as the number of blocks increases, it becomes harder to build a stable tower. But increasing the number of items does not always have a negative impact on performance. For example, it is easier to hide in a room that affords many potential hiding places. It is not clear whether preschoolers appreciate that increasing the number of items can hamper performance in some situations while facilitating performance in others. Yussen and Bird (1979) report that in their pilot studies, children tended to believe that any task could be made more difficult by including more numerous or larger items. This suggests children might initially believe that number is a global variable and that increasing the number of items will hinder performance in all task domains.

Table 8.3. Probability of a Correct Answer as a Function of Age and Type of Task.

	Cognitive		Physical		
Subjects	Memory	Hiding	Tipping	Opening	Mean
Older Pre-schoolers (n = 9; mean age = 5-3)	.89	.89	.78	.78	.83
Younger Pre-schoolers (n = 10; mean age = 3-10)	.50	.40	.50	.50	.53
Mean	.68	.63	.63	.74	.67

The purpose of this final experiment was to see if children initially overgeneralize the effects of stimulus variables, for example, by believing fewer items will always make a task easier, or alternatively, whether they first consider the nature of the task before evaluating the effects of stimulus variables. If children's judgments prove to be task-dependent, we will consider whether they are initially more adept at judging the relative difficulty of physical, as opposed to cognitive tasks.

In our experiment, children were presented with four tasks. Two of these were easier when fewer items were included in the display and the other two were easier when the number of items increased. For each task, children were presented with two displays that only differed in the number of items each contained: one display had three items whereas the other had twelve items. Two of the tasks used pieces from a children's game called Topple. Preschoolers were presented with two unstable platforms perched on a base. One platform contained three yellow pieces, all positioned on the same half of the platform, whereas the other platform contained nine yellow pieces that were also clustered together on the same half of the platform. In the motor version of the task, children were asked which tower would be easier to tip over by adding another piece. Here the platform with the extra pieces would be easier to tip because of its greater unbalanced weight. (The predicted effects of these number variations are summarized in Table 8.2.) The same towers also served as stimuli for a cognitive task. In this task, children were asked to indicate which tower would make it easier to remember where the yellow pieces go. If children understand how this number variation affects memory, they should choose the tower with three pieces.

The stimuli for the other two tasks were pieces of cardboard containing either three or twelve little doors. In the motor task, children were asked where it would be easier to open the doors, and the display with the fewer doors was the right answer. Children were also asked where it would be easier to hide a penny, and for this more cognitive task, the correct response would be that hiding the penny would be easier when the display contained more doors.

As can be seen in Table 8.3, our older preschoolers (mean age: 5-3; range: 4-11 to 5-7) performed extremely well on all four tasks. These children were correct on 83% of the trials, and the few errors that did appear were scattered across all four tasks. In striking contrast, our younger subjects (mean age: 3-10; range: 3-6 to 4-6) found these tasks extremely difficult and were only correct on 53% of the trials. Perhaps more importantly, these children's error patterns did not suggest that they were uniformly adopting a rule that less is easier. If they had, they would have passed two of the tasks and failed the other two. Nor did children's performance vary as a function of the type of task. These general findings were confirmed by a logistic regression using age, type of task (motor vs. cognitive), type of motor task (tipping vs. opening), and type of cognitive task (memory vs. hiding) as the independent variables, and the probability of success on the task as the dependent variable. (We should note that a logistic regression was used rather than classical regression because the dependent variable is discrete rather than continuous, see Abdi, 1987; Hosmer & Lemeshow, 1989.) The effect of age is clearly significant (Wald's χ^2 (1) = 7.08, $p < .01$). The effects of task, type of cognitive task, and type of motor task were not significant (Wald's χ^2 (1) = .07, .13 and .54, n.s., respectively).

These results, then, suggest that children do not assume that stimulus factors will have the same effect on all tasks. Instead, children seem to treat each task as unique and attempt to evaluate the importance of stimulus factors in the context of each activity. This pattern of results, together with the findings of Fabricius et al. (1989), seem to suggest that children are quite sensitive to the differences between various tasks. In fact, it now seems likely that noticing the similarity among different examples of memory tasks, problem solving activities, or fine motor acts may be the real developmental achievement, and we are currently exploring whether children generalize their understanding of stimulus variables across classes of activities.

VII. CONCLUSIONS

In the course of this chapter, we have reviewed a wide range of studies that focus on how children conceive of the human mind. We began by discussing why many cognitive developmentalists have adopted the theory metaphor as a way to characterize cognitive change and have framed our review around Wellman's (1990) view of the child's developing theory of mind. Wellman (e.g., Wellman & Woolley, 1990; Wellman, 1990) has argued that the child's framework theory of mind undergoes major revisions during the preschool years. The child's first theory of mind is characterized by a desire psychology; he or she understands that individuals act to fulfill their desires but does not recognize that these actions are mediated by beliefs. Somewhere around their third birthday, children recognize that an individual's actions are informed by his or her beliefs. For Wellman, this achievement marks an initial commitment to a primitive belief-desire psychology. Not only do three-year-olds understand that mental representations play a role in intentional behavior, they also understand that different kinds of mental representations are possible. Three-year-olds distinguish among dreams, images, and reality-oriented representations, and in their view, reality-oriented representations are veridical copies of the external world. However, at the same time children make these distinctions, they also recognize that these mental entities all share the same ontological status and that these entities all fall within the scope of a theory of mind.

Four-year-olds are beginning to recognize that knowledge-based representations are not simply copied from the outside world. They recognize that beliefs are constructed and that even though beliefs are reality-oriented, they do not always mirror reality. Unlike the younger child, the four-year-old is able to reflect, at least to some extent, on both representations and the processes that construct them. Even three-year-olds, however, have some understanding of process. They recognize, for example, that perceptual processes are independent in the sense that one perceptual modality can be activated while another is not. In our review, we have focused on whether children also grasp more subtle distinctions, such as the difference between seeing and knowing or remembering and attending, and we have concluded that children do distinguish among these processes even though they may lack a complete understanding of how different factors influence processing.

Older preschoolers have been credited with a constructivist view of the mind. Wellman argues that once children reach four years of age, their theory of mind embodies the metaphor of a homunculus that actively interprets and manipulates information. Specific theories can develop within the confines of this constructivist framework. Elementary school children have been credited with both specific theories of self (Damon & Hart, 1988; Harter, 1985; Wellman, 1990) and specific theories of intelligence (Cain & Dweck, 1989; Wellman, 1990). At this point, it is not clear whether children also have specific theories about individual cognitive processes. As Wellman points out, metamemory might be conceived of as a collection of loosely organized pieces of practical lore, general rules, and thoughts about one's own mnemonic abilities. Alternatively, metamemory might be thought of as a specific naive theory of memory. This specific theory would be distinct from other specific theories, such as those focused on attention or other cognitive processes. But given that many complex cognitive activities recruit a variety of cognitive processes, does it really make sense to think that an individual would organize his or her metacognitive knowledge around specific theories that focus on each process in isolation? With some qualifications, we expect this is true.

Philosophers (e.g., Hesse, 1966) and psychologists (e.g., Gentner, 1982) interested in the development of scientific theories have posited that root metaphors guide theorizing and research activities in scientific domains, and that different metaphors lie at the heart of competing theories. Our intuitive understanding of the human mind is undoubtedly rooted in various metaphors. Perhaps, as Wellman claims, homunculi (or even demons, see Selfridge, 1959) underlie our everyday framework theory. It is also likely to be true that the specific everyday theories we hold about individual cognitive processes are rooted in metaphors.

Metaphors surely play a role in formal psychological theories. As Marshall and Fryer (1979) point out, the dominant models of memory have at their core metaphors that can be traced back to the ancient Greeks. For example, variations of the storehouse metaphor have played a central role in memory theories. Plato likened memory to an aviary, and many of the key distinctions this metaphor embodied were elaborated in a subsequent metaphor that likened memory to a well-laid out and well-indexed library. The library metaphor nicely captures many of the organizational issues that were neglected by the aviary metaphor, and Marshall and Fryer argue that most modern accounts of semantic memory build upon specific aspects of this library metaphor. Our understanding of other cognitive processes may be grounded in different metaphors. For example, modern theories of attention make reference to filters, spotlights, and bottlenecks.

It may be significant that each cognitive process has been described by a variety of metaphors, each of which seems to capture certain aspects of the process while glossing over others. For example, the library metaphor is particularly well-suited to questions about long-term memory whereas questions concerning recognition memory may be better addressed by variations of Plato's wax tablet metaphor (see Marshall & Fryer, 1979). The data we presented in the latter part of this chapter suggested that elementary school children distinguish among cognitive processes but the exact nature of these distinctions remains unclear. It is worth noting that our memory and monitoring tasks can each be conceptualized in terms of different metaphors. In the monitoring task, attention might be likened to a spotlight that must be continually moved across the visual field. The memory task can be framed in terms of the library metaphor; the task becomes easier when color can be used to index the target. Perhaps the distinctions children make among cognitive and perceptual processes mirror the different metaphors they use to reason about various aspects of the cognitive system. Thus children may consider activities similar if they can be conceptualized in terms of the same metaphor. Different metaphors highlight different task and situational variables, and children might be expected to generalize their knowledge about the effects of specific variables across activities that share the same root metaphor.

Metaphors play a central role in our intuitive psychology because they make it possible for us to construct mental models that can be used to reason about performance in different tasks and situations (see, e.g., Gentner & Stevens, 1983; Holland, Holyoak, Nisbett & Thagard, 1986). It is interesting to note that the metaphors that we suspect underlie specific theories within our everyday psychology typically make a distinction between representation and process. Representations are likened to tangible things, such as birds or books, that physical acts can be performed on whereas processes are likened to the actions that can be performed on these objects. Perhaps this distinction between representation and process is just as central to our everyday theory of mind as it is to theories in cognitive psychology.

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Commentary

Reflecting on Representation and Process: Children's Understanding of Cognition, S. E. Barrett, H. Abdi, & J. M. Sniffen

DENNIS H. HOLDING
University of Louisville

Perhaps we do use metaphors in our theories, and in constructing the mental models that underlie our reasoning about interaction with the world. In a sense it could hardly be otherwise, since all of our abstract words are originally metaphors, even when disguised in a Latin form. The word "abstract," after all, is simply the participle from "abs-" and "trahere" and thus corresponds to something like "outdrawn" or perhaps "dragged away from." Whether or not something functions as a metaphor is a matter of degree, depending on how much of the literal meaning is still present for users of the language. Perhaps then, children are aware of fewer literal associations and might therefore be said to employ fewer metaphors than adults.

Despite the emphasis of their conclusions Barrett, Abdi and Sniffen do not direct their efforts toward addressing the problem of children's metaphors. What the experiments show, instead, is that children do make metacognitive distinctions between the mental Processes (but not Structures) demanded by different task requirements. By and large, their judgments concur with those of young adults, both groups assuming, for example, that (skin) color is irrelevant to herding goats but that increased size would be a disadvantage. On the other hand, color should help in remembering the location of a sick chicken, while size is treated as irrelevant. However, unlike the adults, the children are less than unanimous in discounting size as an aid to memory.

What worries me about this, as an experimentalist, is that all we know is what the subjects say they expect would happen. But what would a memory test show? Perhaps the children are right. Perhaps they would remember larger chicken coops better because they would discriminate them better. Large letters are an aid to reading, and possibly to memory, and one might predict that minuscule chicken coops would be quite difficult to remember apart. In general, one ought probably to be cautious about obtaining information on metacognition without corresponding information about the cognition itself. This said, there is no doubt that children's judgments do imply that different tasks are seen as requiring different processes.