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CHAPTER 8

Cognition: Piaget and Vygotsky

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CHAPTER RECAP

Summary of Developmental Themes
Summary of Topics

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Key Themes in Cognition

- **Nature/Nurture** What roles do nature and nurture play in cognitive development?
- **Sociocultural Influence** How does the sociocultural context influence cognitive development?
- **Child's Active Role** How does the child play an active role in the process of cognitive development?
- **Continuity/Discontinuity** Is cognitive development continuous or discontinuous?
- **Individual Differences** How prominent are individual differences in cognitive development?
- **Interaction Among Domains** How does cognitive development interact with development in other domains?

"Jeremy! Let's play hide-and-seek!" shouted Tommy to his three-year-old brother. "See. You hide. I'll count to ten. Then I'll find you. It's fun, Jeremy. Let's try it." Tommy took special pride in being a big brother; with seven years between them, he often baby-sat while his parents did chores around the house, and he especially enjoyed teaching Jeremy new things like this favorite childhood game of his.

"Okay," smiled Jeremy. "I hide." The toddler stepped carefully over the family's Labrador retriever and plunked himself squarely behind the couch, or so he thought since he could not see his older brother. In the distance, he heard Tommy say, "Ten! Ready or not, here I come!" and held his breath. In barely a few seconds, though, Tommy was right in front of him, grinning widely. "Silly Jeremy," chuckled Tommy, "You can't let your legs stick out like that from behind the couch. I can see you!"

One of the most active research areas of child development focuses on **cognition**—those thought processes and mental activities, including attention, memory, concept formation, and problem solving, that are evident from early infancy onward. As the scene above suggests, younger children seem to think differently than older children. They do not understand, for example, that other individuals may have different information about the world than they themselves do. In what other ways do children of different ages think differently? Do young children remember as well as older children do? Do older children solve problems the same way younger children do? These are the types of questions that psychologists interested in cognitive development ask.

Virtually every aspect of a child's development has some connection to emerging cognitive capabilities. We saw in the chapter titled "Language" that a child's use of language is linked to his or her growing conceptual development. Similarly, as we will discuss in later chapters, the child's increasing knowledge of effective social interaction can influence the quality of relations with peers. You should find numerous examples throughout this text of how changes in thinking influence and interact with other areas of the child's development.

In this chapter, we focus our discussion of cognitive development on two of the most important theoretical positions framing research on children's thought: those of Jean Piaget and Lev Vygotsky. Jean Piaget (1896–1980) was a Swiss psychologist whose childhood interest in biology evolved into a general curiosity about how individuals acquire knowledge. Piaget saw himself as a *genetic epistomologist,* a scholar who was interested in the origins of knowledge from a developmental perspective. His desire to understand children's intellectual growth was probably sparked by his experiences working in the laboratories of Alfred Binet, in which the first intelligence test was developed. From the early 1920s, when his first books were published, to 1980, when he died, Piaget authored more than seventy books and scores of articles describing various aspects of children's thinking. Lev Vygotsky (1896–1934), too,

cognition Processes involved in thinking and mental activity, such as attention, memory, and problem solving.

began his work in the early part of the twentieth century. Growing up in Russia at a time of great social and political upheaval—the Marxist revolution—and no doubt influenced by the vigorous intellectual debates of the times, Vygotsky authored several landmark essays outlining his ideas on language, thought, and the sociocultural environment. His untimely death at the age of 38 cut short a rich and promising academic career.

We begin by summarizing Piaget's major ideas and evaluating his contributions to our understanding of cognitive development. We also discuss several topics explored by contemporary researchers influenced or provoked by Piaget's writings, including the development of children's understanding of physical objects, their ability to classify objects, and their understanding of concepts such as number, space, and psychological states. Finally, we review the major features of Vygotsky's sociocultural theory of development, along with research that his work has stimulated.

Piaget's Theory of Cognitive Development

KEY THEME
Child's Active Role

As we saw in the chapter titled "Themes and Theories," one of the most important beliefs espoused by Piaget is that children actively construct their knowledge of the world, incorporating new information into existing knowledge structures, or *schemes,* through *assimilation*. As a result, schemes are modified or expanded through the process of *accommodation*. For example, the young infant may attempt to grasp a new, round squeeze toy, relying on a pre-existing scheme for grasping objects. As a consequence, that scheme becomes altered to include information about grasping round objects. The outcome is greater *equilibrium* or balance among the pieces of knowledge that make up the child's understanding. Thus what a child can understand or mentally grasp at any given point in time is heavily influenced by what the child already knows or understands. At the same time, the child's schemes are constantly transformed, as equilibrium is continually disrupted by the never-ending flow of information from the surrounding world.

KEY THEME
Continuity/Discontinuity

Piaget maintained that thought processes become reorganized into distinct stages at several points in development. Though the schemes in early stages lay the foundation for later knowledge structures, their reorganization is so thorough that schemes in one stage bear little resemblance to those in other stages. According to Piaget, the child progresses through the *sensorimotor, preoperational, concrete operational,* and *formal operational* stages, reflecting major transitions in thought in which early, action-based schemes evolve into symbolic, then logical, and finally abstract mental structures.

Stages of Development

KEY THEME
Nature/Nurture

Piaget maintained that all children progress through the stages of cognitive development in an invariable sequence in which no stage is skipped. In addition, each stage contains a period of formation and a period of attainment. When the child begins a new stage, his schemes are somewhat unstable and loosely organized. By the end of the stage, his schemes are well formed and well organized. Even though Piaget provided age norms for the acquisition of each stage, he believed that because cognitive development is the result of maturational factors working in concert with environmental experiences, some children may reach a stage more quickly or more slowly, depending on the opportunities for learning their environment provided. Ultimately, though, the evolution of thought shows a universal regularity, according to Piaget.

sensorimotor stage In Piagetian theory, the first stage of cognitive development, from birth to approximately two years of age, in which thought is based primarily on action.

● **The Sensorimotor Stage (Birth to Two Years)** The most striking characteristic of human thinking during the **sensorimotor stage** is its solid basis in action. Each time the child reaches for an object, sucks on a nipple, or crawls along the floor, she is obtaining varied feedback about her body and its relationship to the environment that becomes part of her internal schemes. At first, the infant's movements are reflexive, not deliberate or planned. As the child passes through each of the six sub-

TABLE 8.1 The Six Substages of Piaget's Sensorimotor Stage

Substage	Major Features	Object Concept
Reflexive Activity (Birth–1 month)	Formation and modification of early schemes based on reflexes such as sucking, looking, and grasping	No attempt to locate objects that have disappeared
Primary Circular Reactions (1–4 months)	Repetition of behaviors that produce interesting results centered on own body (e.g., Lucienne accidentally, then repeatedly, touches her quilt)	No attempt to locate objects that have disappeared
Secondary Circular Reactions (4–8 months)	Repetition of behaviors that produce interesting results in the external world (e.g., Lucienne accidentally, then repeatedly, kicks the dolls in her bassinet)	Search for objects that have dropped from view or are partially hidden
Coordination of Secondary Schemes (8–12 months)	Combination of actions to achieve a goal (e.g., Lucienne pulls a doll to make her bassinet hood sway)	Search for completely hidden objects
Tertiary Circular Reactions (12–18 months)	Experimentation with different actions to achieve the same goal or observe the outcomes (e.g., Laurent drops a case of soap, then a piece of bread)	Ability to follow visible displacements of an object
Invention of New Means Through Mental Combinations (18–24 months)	Thinking through of potential solutions to problems and imitation of absent models (e.g., Jacqueline imitates her playmate's tantrum)	Ability to follow invisible displacements of an object

stages of the sensorimotor period, outlined in Table 8.1, her actions become increasingly goal directed and aimed at solving problems. Moreover, she is able to distinguish self from environment and learns about the properties of objects and how they are related to one another.

A significant accomplishment of the sensorimotor stage is the infant's progression toward **means-ends behavior,** the deliberate use of an action to accomplish some goal. During the early substages of sensorimotor development, the infant often initiates actions accidentally rather than purposefully. When Piaget's daughter Lucienne was almost four months old, she was observed to shake her bassinet

> *by moving her legs violently (bending and unbending them, etc.), which makes the cloth dolls swing from the hood. Lucienne looks at them, smiling, and recommences at once.* (Piaget, 1952b, pp. 157–158)

Lucienne repeated her kicking to make the dolls shake in what Piaget calls a *circular reaction,* the repetition of a motor act to experience the pleasure it brings. Her first kick, however, was totally accidental. Several months afterward, when Lucienne was eight months old, Piaget placed a new doll over the hood of her bassinet. This time her behavior revealed a greater degree of intentionality:

> *She looks at it for a long time, touches it, then feels it by touching its feet, clothes, head, etc. She then ventures to grasp it, which makes the hood sway. She then pulls the doll while watching the effects of this movement.* (Piaget, 1952b, p. 256)

Throughout the first two years, the child increasingly uses actions as a means to obtain some end or goal. He also experiments with new means to reach the same goal,

means-ends behavior Deliberate behavior employed to attain a goal.

A significant attainment in infancy is the child's understanding of object permanence. Children under three to four months of age act as if a hidden or obstructed object no longer exists. By age eight months, though, children will remove a barrier to look for a hidden object.

as Piaget's son Laurent did when he successively dropped a soap case and then a piece of bread to investigate how objects fall.

A second aspect of sensorimotor development is the child's gradual separation of self from the external environment. Initially, the child derives pleasure from actions that center on her own body. At three months of age, Lucienne "strikes her quilt with her right hand; she scratches it while carefully watching what she is doing, then lets it go, grasps it again, etc." (Piaget, 1952b, p. 92). The circular reaction, in this case, was repeated because of the satisfying sensations it brought to Lucienne's hand. Weeks later, in the episode of the swinging dolls, Lucienne's kicking in the bassinet produced a gratifying result in the external environment. In general, the child becomes less centered on the self and more oriented to the external world.

A third important accomplishment of this stage is the attainment of the **object concept,** or *object permanence*. Infants who possess the object concept realize that objects continue to exist even though they are not within immediate sight or within reach to be acted on. Up to three months of age, the saying "out of sight, out of mind" characterizes the child's understanding of objects. At about four months of age, he will lift a cloth from a partially covered object or show some reaction, such as surprise or puzzlement, when an object disappears. At about eight months of age, he will search for an object that has completely disappeared, for example, when it has been covered entirely by a cloth. In the last two phases of the attainment of the object concept, he will be able to follow visible and then invisible displacements of the object. In the first instance, the twelve-month-old will follow and find a toy that has been moved from under one cloth to another, as long as the movement is performed while he is watching. In the second instance, the eighteen-month-old can find an object moved from location A to location B, even if the displacement from A to B is done while he is not looking.

object concept Realization that objects exist even when they are not within view. Also called *object permanence*.

The completion of the sensorimotor stage and the beginning of the next stage is signaled by the child's display of *deferred imitation,* the ability to imitate a model who is no longer present. At age sixteen months, Piaget's daughter Jacqueline was playing with a boy who suddenly had a dramatic temper tantrum. The next day, the normally well-behaved Jacqueline mimicked the little boy's behaviors with remarkable accuracy. To do so, she must have had the ability to *represent* the boy's overt behaviors in internal form and to draw on that representation hours later. This ability to represent events and objects internally marks the beginning of a major transition in thought.

The Preoperational Stage (About Two to Seven Years) The key feature of the young child's thought in the **preoperational stage** is the *semiotic function,* the child's ability to use a symbol, an object, or a word to stand for something. The child can play with a cardboard tube as though it were a car or draw a picture to represent the balloons from her third birthday party. The semiotic function is a powerful cognitive ability because it permits the child to think about past and future events and to employ language. In fact, Piaget asserted that language would not be possible without this significant characteristic of thought; the child must possess the general cognitive ability to let one thing stand for another before she can use words to represent objects, events, and relationships. The semiotic function is also a prerequisite for imitation, imagery, fantasy play, and drawing, all of which the preschool child begins to manifest.

Despite this tremendous advance in thinking, preoperational thought has distinct limitations. One is that children in this stage are said to be **egocentric,** a term that describes the child's inability to separate his own perspective from those of others. Put into words, his guiding principle might be "You see what I see, you think what I think," much like Jeremy in this chapter's opening scene, who thinks he is hiding from his older brother by crouching behind a couch. Even though his legs and feet might be sticking out for all present to see, the youngster believes he is well concealed because he himself is unable to see anyone. According to Piaget, the preschooler's egocentrism has ramifications for both his social communicative behavior and his perceptual skills. Piagetian theory predicts poor referential communication skills in children under age seven years and, as we will see later in this chapter, the inability to appreciate the perspectives of others in perceptual tasks.

KEY THEME
Interaction Among Domains

The second limitation of preoperational thought lies in the child's inability to solve problems flexibly and logically. The major tasks Piaget used to assess the status of the child's cognitive development are called the **conservation tasks.** These "thinking problems" generally require the child to observe some transformation in physical quantities that are initially equivalent and to reason about the impact of the transformation. Figure 8.1 shows several conservation tasks.

We can use the conservation of liquid quantity task to illustrate how the preoperational child thinks. The four- or five-year-old will usually quickly agree that two equal-size glasses of water contain the same amount of liquid. If the liquid from one glass is poured into a tall cylinder, however, the child will state that the cylinder now contains more than the glass does. According to Piaget, this error is the result of several limitations in preoperational thinking. One is **centration,** that is, focusing on one aspect of the problem—in this case, the height of the cylinder—to the exclusion of all other information, such as its narrower width, that could help to produce a correct solution. A second cognitive trait at work here is lack of **reversibility.** The preoperational child cannot mentally reverse the action of pouring from the tall cylinder to the shorter glass; if she could, she would realize that the two containers still hold the same amount of liquid that they did at the start of the problem. Third, the preoperational child tends to **focus on states** rather than on the events that occur between states. It is as though he has stored two static photographs of the two equal-size glasses, followed by static photographs of the shorter glass and the tall cylinder, rather than a video of the sequence of events. He fails to realize the connection between the two components of the conservation problem and, as a result, fails the conservation task.

The Concrete Operational Stage (About Seven to Eleven Years) Children enter the **concrete operational stage** when they begin to be able to solve the conservation tasks correctly. At first, the six- or seven-year-old may solve only a few of the simpler problems, such as conservation of length, number, or liquid quantity. Later, she will succeed on tasks that involve area or volume. Piaget called this extension of the same cognitive structures to solve increasingly difficult problems within a given stage *horizontal décalage.*

preoperational stage In Piagetian theory, the second stage of development, from approximately two to seven years of age, in which thought becomes symbolic in form.

egocentrism Preoperational child's inability to separate his or her own perspective from those of others.

conservation tasks Problems that require the child to make judgments about the equivalence of two displays; used to assess stage of cognitive development.

centration In Piagetian theory, tendency of the child to focus on only one aspect of a problem.

reversibility In Piagetian theory, the ability to mentally reverse or negate an action or a transformation.

focus on states Preoperational child's tendency to treat two or more connected events as unrelated.

concrete operational stage In Piagetian theory, the third stage of development, from approximately seven to eleven years of age, in which thought is logical when stimuli are physically present.

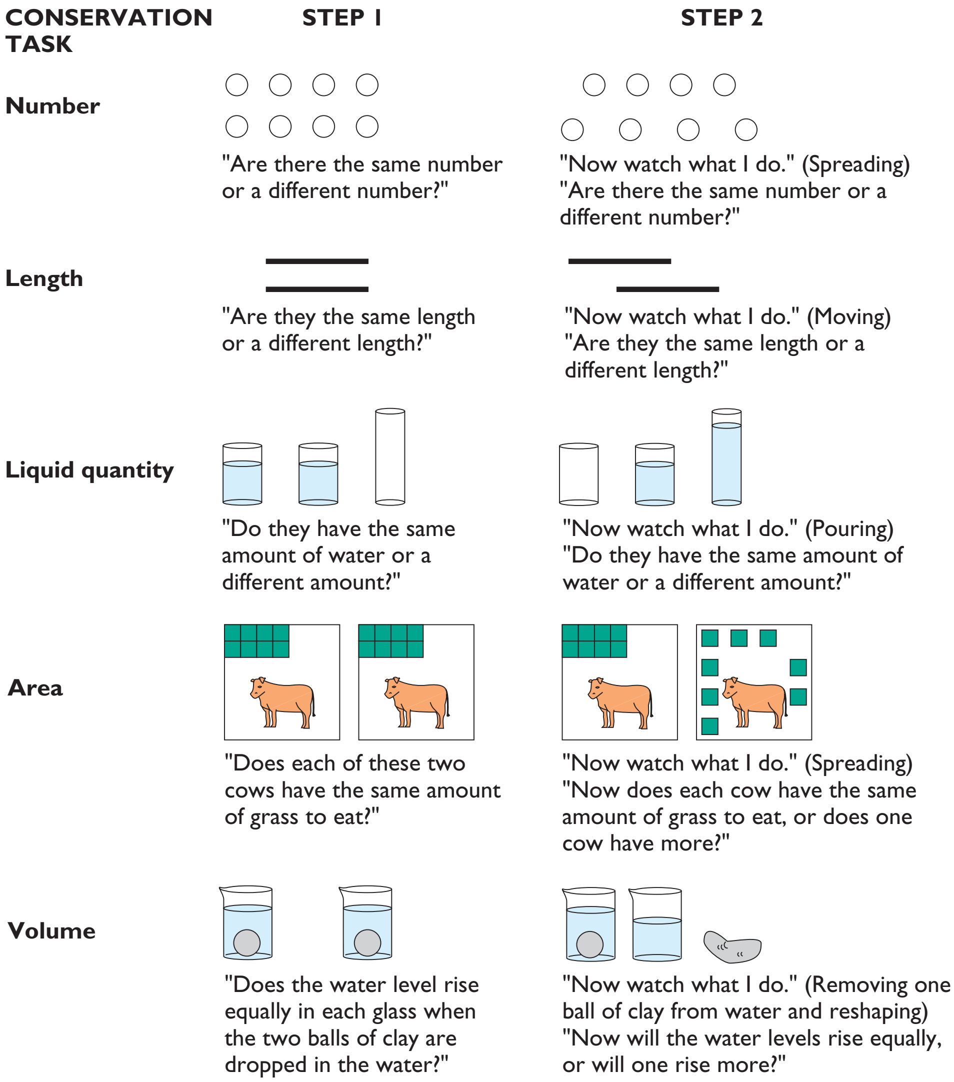

FIGURE 8.1
Examples of Conservation Tasks

Depicted here are several Piagetian conservation tasks that children can solve once they reach the stage of concrete operations. Preoperational children usually say the quantities change after the transformation. Piaget believed they lack the logical thought structures necessary to reason correctly.

The reason for this shift is that the child is now capable of performing **operations,** mental actions such as *reversibility,* that allow him to reason about the events that have transpired. He can pour the liquid back from the cylinder to the glass "in his head" or think about the narrow width of the tall cylinder as compensating for its height. In other words, the child now thinks logically, although the physical components of the problem must still be present (if not externally in the world, then as images in the mind). The child's growing logical capabilities are also manifested in his ability to *seriate* objects, putting sticks of varied lengths into a systematic series arranged from shortest to longest, for example. Unlike the preoperational child who performs this task in a haphazard way, the concrete operational child starts with the shortest (or tallest) and compares each successive stick with those that are shorter and longer so that an orderly array results. The child's thought in this stage is also less egocentric, allowing him to understand that other individuals' perceptions, beliefs, and feelings may differ from his own. The concrete operational child is becoming a true "thinker," as long as there are specific objects or events to which he can apply his logic.

operation In Piagetian theory, a mental action such as reversibility.

formal operational stage In Piagetian theory, the last stage of development, from approximately eleven to fifteen years of age, in which thought is abstract and hypothetical.

● **The Formal Operational Stage (About Eleven Years and Beyond)** By the time the child reaches adolescence, she will most likely have moved to the final stage in Piaget's theory, the **formal operational stage.** Thinking in this stage is both logical and abstract. Problems such as "Bill is shorter than Sam but taller than Jim. Who is tallest?" can now be solved without seeing the individuals or conjuring up concrete images of them. The adolescent can also reason **hypothetically;** that is, she can generate potential solutions to problems in a thoroughly systematic fashion, much as a scientist approaches an experiment.

Piaget's pendulum problem allows us to examine the thinking of the formal operational adolescent. In this task, the person is shown an object hanging from a string and asked to determine the factor that influences the frequency of oscillation, or the rate at which the pendulum swings. The length of the string, the weight of the object, the force of the push on the object, and the height from which the object is released can all be varied. How do children in earlier Piagetian stages approach this problem? Children in the preoperational and concrete operational stages typically try various manipulations in a haphazard fashion. They might compare the effect of a long string attached to a heavy weight and a short string tied to a light weight. Or they might vary the weight of the object and force of the push but leave out the length of the string. In contrast, formal operational children are both systematic and complete in testing the potential influences on oscillation. For example, while keeping weight constant, they observe the effects of varying length, push, and height; while keeping length the same, they investigate the effects of varying weight, push, and height; and so forth. Most adolescents, Piaget observed, could correctly determine that the length of the string was the critical factor in how fast the pendulum swings (Inhelder & Piaget, 1958).

In the social realm, achieving abstract thought means the adolescent can think about the nature of society and his own future role in it. Idealism is common at this developmental stage because he understands more fully concepts such as justice, love, and liberty and thinks about possibilities rather than just realities. In some ways, the adolescent may be more of a "dreamer" or utopian than the adult because he has not yet had to confront the practical facts of living and working in the world (Inhelder & Piaget, 1958).

The contemplative nature of adolescent thought may manifest itself in two other ways, according to David Elkind (1976, 1981). First, adolescents may believe others scrutinize and evaluate them as much as they think about themselves. This belief, called the **imaginary audience,** may cause a young girl to avoid going out because she just got braces on her teeth ("Everybody will see me!") or make a teenage boy avoid answering a question in class because he is certain all his classmates will think he is "dumb." Second, adolescents may show signs of holding a **personal fable,** the belief that they are unique, that no one can fully understand them, and even that they are invulnerable. A teenage boy prohibited from going to a late-night rock concert by his parents might say, "You just don't understand how important this is to me!"

The development of formal operational thought represents the culmination of the reorganizations in thought that have taken place throughout each stage in childhood. By adolescence thought has become logical, flexible, and abstract, and its internal guiding structures are now highly organized.

Implications for Education

Piaget's theory carries some clear implications for teaching children. The first is that the individual child's current stage of development must be carefully taken into account as teachers plan lessons. For example, a seven-year-old who is in the stage of concrete operations should be given problems involving actual physical objects to observe or manipulate rather than abstract word problems or diagrams (Flavell, 1963). Similarly, a four-year-old preoperational child may have difficulty with tasks requiring the use of logic; a more fruitful strategy might be to foster the imagination and creativity that result from the recently acquired semiotic function. By encouraging drawing, pretend play, and vocal expression, teachers can capitalize on the preschooler's cognitive strengths.

A second, related implication is that what the child knows already will determine what new information she is able to absorb. Because her current cognitive structures

hypothetical reasoning Ability to systematically generate and evaluate potential solutions to a problem.

imaginary audience Individual's belief that others are examining and evaluating him or her.

personal fable Belief that one is unique and perhaps even invulnerable.

Piaget believed that active learning promotes deeper and more enduring understanding than rote memorization. One implication of this hypothesis is that educators should try to provide children with hands-on activities to promote their understanding of subjects such as mathematics and science.

limit what she will be able to assimilate, it is important that the teacher be aware of the child's current state of knowledge. In addition, cognitive advances are most optimally made when new material is only slightly different from what the child already knows (Ginsburg & Opper, 1988). Thus the teacher's task is to plan lessons that are tailored to the needs of the individual child rather than to the class as a whole and to be flexible in devising instructional materials that stretch the child one step beyond what she already knows.

KEY THEME
Child's Active Role

One of Piaget's most important statements about cognitive development is that it is the result of the *active engagement of the child*. Early sensorimotor schemes and later mental operations are all founded first on the child's physical activity and later on mental actions. Thus education too must be structured in such a way that it will promote the child's active participation. Instead of emphasizing rote learning, teachers following a Piagetian model provide children with experiments that allow them to discover scientific principles on their own. Children do not memorize numerical relationships, such as the multiplication tables, but discover them by manipulating sets of objects under the close guidance of the teacher. According to Piagetian thinking, active learning of this sort promotes deeper and more enduring understanding.

Evaluating Piaget's Theory

Piaget is widely acknowledged as being one of the most influential of all thinkers in the history of psychology and a founder of the study of cognitive development as we know it (Brainerd, 1996; Flavell, 1996). By introducing questions about *what* develops as well as *how* development occurs, Piaget went well beyond the descriptions of norms of behavior that had been the staple of the early years of research in developmental psychology. Moreover, once American psychologists learned of his ideas in the 1960s and early 1970s, they could no longer conceptualize development solely in terms of learning theory, which was a dominant psychological view at that time. Finally, Piaget's method of closely watching the nuances of children's behaviors and listening as they explained their reasoning provided an important and inspiring lesson for developmental psychologists: that "grand questions can actually be answered by paying attention to the small details of the daily lives of our children" (Gopnik, 1996, p. 225).

The fact that Piaget's theory has stimulated so much research in developmental psychology is not surprising, given its wide-ranging scope. In sheer numbers of empirical studies generated by the writings of one person, Jean Piaget has no rival in developmental psychology. Like all good theories, Piaget's has spawned a host of debates about the fundamental nature of cognitive change. These debates are a tribute to the power of his ideas and his contribution to the scientific process.

How Competent Are Young Children? One criticism of Piaget's theory is that Piaget underestimated the abilities of infants and young children. Many researchers have found that when cognitive tasks are simplified or restructured, children display cognitive skills at much earlier ages than Piaget believed possible.

Take the object concept, for example. Piaget maintained that the first real notions about the permanence of objects do not emerge until about eight or nine months of age, when infants will search for objects that are completely covered. In an experiment more fully described in the next Examining Research Methods feature, however, Renée Baillargeon (1987a) believes she has obtained evidence that infants as young as four months of age have a rudimentary understanding of the continuing existence of objects. Even though this study has been criticized on methodological grounds, other research suggests that young infants possess a surprising degree of knowledge about objects and their properties (Bremner, 1998). For example, six-and-a-half-month-old infants will reach in the dark for an object they had earlier seen in the light. Simply reaching is a much easier sequence of motor actions than reaching for and uncovering a hidden object (Goubet & Clifton, 1998). Thus these infants apparently had some form of the object concept.

Many other studies described later in this chapter and in the chapter titled "Cognition: Information Processing" indicate that young children are not as egocentric and illogical as Piaget thought. Piaget himself was less concerned with the specific ages at which children acquire cognitive skills than with the sequence of development. However, the fact that many cognitive attainments occur earlier than he suggested challenges the notion that young children must gradually build up their knowledge of the world over time.

EXAMINING RESEARCH METHODS

Ensuring Experimental Control in Studying the Object Concept

Is it possible to demonstrate knowledge about the continuing existence of objects in very young infants? Renée Baillargeon (1987a) conducted a unique experiment in which four-month-olds behaved as if they understood that an object continued to exist even when it was concealed by a screen. Figure 8.2 shows the phases of this experiment. At first, infants observed a screen that rotated back and forth 180 degrees over repeated trials. As you might expect, they eventually showed habituation of visual fixation to this display. Next, a box was placed behind the screen. Initially, when the screen was still flat against the table, the box was visible, but as the screen rotated away from the child, it hid the box from view. In the possible-event condition, the screen stopped moving at the point where it hit the box. In the impossible-event condition, the box was surreptitiously removed and the screen passed through the space the box would have occupied. As you learned in the chapter titled "Basic Learning and Perception," infants in a habituation experiment should look longer at the novel event, in this case, the screen that rotated only 112 degrees. However, infants looked significantly longer at the impossible event, apparently drawn in by the fact that the screen was moving through the space where the object should have

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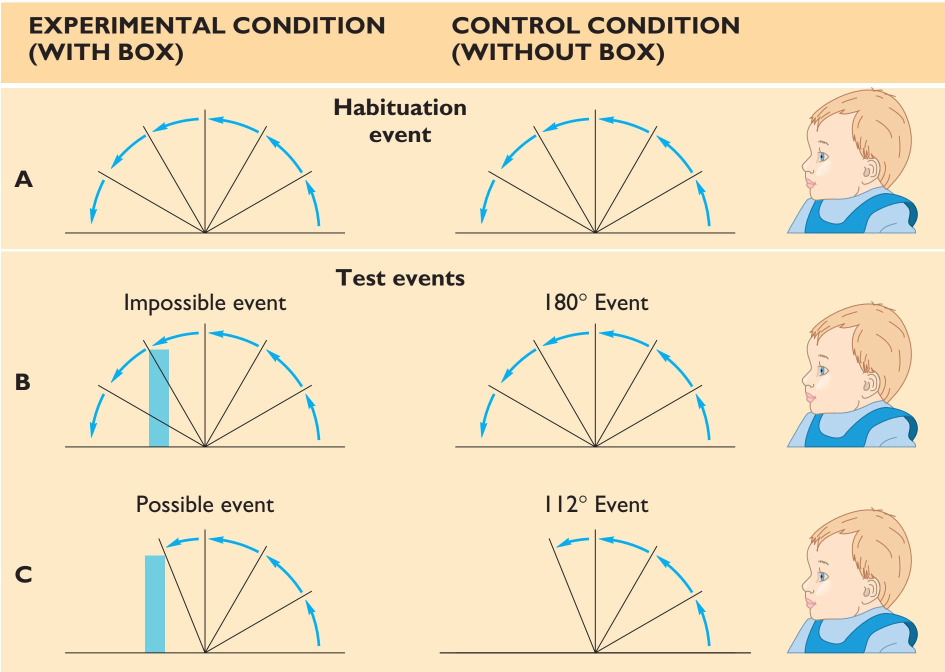
Testing Object Concept

FIGURE 8.2
Do Infants Have an Object Concept?

In Baillargeon's experiment, infants were habituated to a screen rotating 180 degrees (A). Next, infants in the *impossible-event* condition saw the screen appearing to pass through the location of a box (B, on left), whereas infants in the possible-event condition saw the screen stop at the location of the box (C, on left). Infants in the *impossible-event* condition looked significantly longer at this event, suggesting that they were puzzled by what they saw and therefore had an object concept. The control conditions (shown at right) were included to make sure the infants were not responding to the arc of the screen's movement.



Source: Adapted from Baillargeon, 1987a.

been. Because infants are presumed to look longer at the stimulus display that goes against their internal knowledge, this procedure is often called the *violation-of-expectation* method.

Before the researcher could conclude that infants had the object concept, however, she had to rule out alternative explanations for the results. This tactic is the hallmark of the experimental method, by which researchers try to make sure that only one variable (and not other simultaneously occurring factors) explains the results. For example, what if infants simply prefer an arc of 180 degrees compared with an arc of 112 degrees, whether there is a box or not? Baillargeon included a control group of infants who saw the original habituation event followed by each of the test events (180 and 112 degrees) but without a box. In this condition, infants did not show preferences for the 180-degree rotation, indicating that the arc of the movement did not influence infants' responses.

Are there any other explanations for the results Baillargeon obtained? As noted, the possible test event was conceptualized by the experimenter as a novel occurrence. Some researchers point out, though, that the impossible test event (the screen rotating 180 degrees apparently through the box) also contains novel elements; the presence of the box makes the event different from the original habituation event. Thus novelty, and not knowledge about objects, could account for looking at the impossible event. In addition, there are some circumstances, particularly in the early stages of processing, in which infants may show a preference for familiar, rather than novel, stimuli. Preference for the impossible event could actually be based on a preference for *familiarity,* the 180-degree rotation, as opposed to knowledge about objects (Bogartz & Shinskey, 1998; Bogartz, Shinskey, & Speaker, 1997).

As you can see from this experiment, establishing experimental control is not always easy or simple. On the surface, the original Baillargeon experiment seemed to be well designed, with the appropriate experimental controls. Researchers should always be asking themselves, though, whether any other competing variables could explain the observed data—that is, have they controlled for all the variables that could possibly be present?

KEY THEME
Continuity/Discontinuity

Is Cognitive Development Stagelike? If cognitive development proceeds in stages, children should show common features in how they think within a stage and distinctive differences in how they think across stages. One problem with Piagetian theory is that it posits more consistency in performance within a given stage than is actually found in the behavior of children. In one study, Ina Uzgiris (1968) tested children who should have been in the stage of concrete operations on conservation of quantity, weight, and volume. The same tasks were tested with different materials, such as plasticine balls, metal cubes, and plastic wires. Many children were able to conserve when one material (say, plasticine balls) was used but not when another (say, metal cubes) was employed. If conservation is indeed tied to the presence of logical thought structures, it should not matter which materials are used to conduct the conservation tests.

Other researchers have noted that the correlations among various abilities predicted to co-occur within the stage of concrete operations are much lower than would be expected if development were truly stagelike (Gelman & Baillargeon, 1983). Piaget maintained, for example, that before children can conserve number they must understand the principle of class inclusion, the idea that some groups of objects are subsets within a larger set. "Dogs" are a subset of "animals," just as "five" is a set contained within "six." Yet children can conserve number by age six or seven and still not fully understand the concept of class inclusion (Brainerd, 1978a).

Many contemporary researchers now believe development shows more continuity than Piaget suggested. What seems to vary among children of different ages, say the critics, is not their cognitive skills but the degree to which the same basic skills are displayed in a wide variety of increasingly complex situations (Brainerd, 1978b).

Is Cognitive Development a General Process? Piaget maintained that, for the most part, changes in mental structures are broad, sweeping reorganizations that influence thinking in multiple domains. Development, in this view, is said to be *domain-general*. However, some theorists maintain that advances in thinking occur more rapidly in some domains than others; that is, development is seen as *domain-specific* (Hirschfeld & Gelman, 1994).

One example of domain-specific processes is children's rapid acquisition of certain concepts, such as the properties of biological entities. Children seem to acquire a vast amount of information about animals, plants, and other living things at very young ages and at a particularly rapid pace (Gelman & Williams, 1998). In addition, this knowledge does not seem to "spill over" into other kinds of conceptual understanding. Children's acquisition of basic numerical concepts and their understanding of physical causality are other candidates for domain-specific knowledge. We will have more to say about each of these concepts in the next section of this chapter, "Concept Development."

Are There Alternative Explanations for Development? Many studies have confirmed Piaget's general claims about the patterns of behavior children display at different ages. Without special training, for example, most children under age six or seven years fail conservation tasks, whereas older children perform them successfully. Adolescents are indeed capable of solving problems more systematically and abstractly than their younger counterparts. Yet many psychologists disagree with Piaget about the precise mechanisms that account for such patterns in the development of thinking processes.

The basic challenge to Piaget's theory centers on whether cognitive development is best understood in terms of emerging symbolic, logical, and hypothetical thought structures or whether some other explanation is more tenable. A case in point is the successful training of conservation by Rochel Gelman (1969). Gelman suggests that young children normally fail conservation tasks because they fail to attend to the correct portions of the problem, not because they lack mental operations such as reversibility. If children's attention is directed to the salient cues, such as length or number, Gelman and others argue, they will be successful in conserving. Younger children may also be less skilled at remembering than older children, forgetting elements of problems that are essential to reaching the correct solutions. Thus cognitive development may result from a change in how information is gathered, manipulated, and stored rather than from the alteration of cognitive structures themselves.

KEY THEME
Nature/Nurture

KEY THEME
Individual Differences

KEY THEME
Sociocultural Influence

Another central Piagetian tenet is that maturation, in conjunction with experience, is responsible for the unfolding of more sophisticated thought structures. The emphasis Piaget places on maturation implies that the sequence of development is universal. Yet not all children reach the stage of formal operations, and some do not even attain the highest levels of concrete operations. Many American adults, in fact, fail to display formal operational thought (Neimark, 1979). Members of many non-Western cultures do not display formal operational thinking, especially when they have little experience with formal schooling (Dasen, 1972; Rogoff, 1981). At the same time, specific kinds of cultural experiences may accelerate the emergence of conservation and formal operational thought. Douglass Price-Williams and his colleagues examined two groups of rural Mexican children six to nine years old on standard conservation problems (Price-Williams, Gordon, & Ramirez, 1969). Half of the children came from pottery-making families, the other half from families that practiced other trades. Children who had experience in manipulating clay for pottery making were far more likely to conserve than the other children. Other research shows that adolescents today receive higher scores on tests of formal operations than adolescents did twenty and thirty years ago (Flieller, 1999). Studies such as these imply that the child's experiences in the sociocultural context may shape the nature of thought to a greater degree than Piaget acknowledged.

Neo-Piagetian Approaches

Several developmental psychologists have modified and expanded Piaget's theory to address some of the criticisms discussed here. Because their ideas build on those Piaget initially proposed, these theorists are often called *neo-Piagetians*. Like Piaget, neo-Piagetians believe children show distinct, even stagelike advances in general thinking skills, probably because of maturation. They also agree that what children know at a given time heavily influences what they will be able to learn and think about. Neo-Piagetians, though, are much more willing than Piaget was to acknowledge the role specific experiences play in shaping the child's knowledge in a given area (Flavell, 1992).

KEY THEME
Continuity/Discontinuity

KEY THEME
Nature/Nurture

Fischer's Skill Theory Kurt Fischer, like Piaget, believes the emergence of general, broad thinking skills contributes to cognitive development (Fischer, 1980; Fischer & Farrar, 1988; Fischer & Pipp, 1984). These skills, he proposes, are organized into four stages or "tiers": reflex, sensorimotor, representational, and abstract. Unlike Piaget, though, Fischer adds that within the same individual, skills may develop more rapidly in some domains—say, numerical understanding or classifying familiar objects—than others, depending on the child's experiences. The child who is given ample access to art materials but not to math problems, for example, may show greater skill in the first area than the second.

KEY THEME
Individual Differences

In Fischer's theory, skills are similar to Piaget's schemes: mental structures that stem from action. In contrast to schemes, however, which are highly generalized structures, skills are more specific to particular objects and tasks. If the environment supports a variety of skills, development in all skills will proceed relatively evenly. Fischer suggests, however, that uniform access to skill development is unlikely. At any one time in development, most children show different levels of skill depending on the domain, be it numerical reasoning, spatial understanding, classification of objects, or some other. Specific skills used in limited contexts eventually become more powerful and are used in more generalized contexts (Fischer & Bidell, 1991). By emphasizing the emergence of separate skills that are heavily dependent on the specific experiences available to the child, Fischer offers a picture of development that is more continuous and gradual than that proposed by Piaget.

Case's Theory Robbie Case (1985, 1992) proposed four stages of development similar to those outlined by Piaget. He theorized that infants begin life with certain innate but limited capacities and attentional resources. Through both maturation and sensorimotor practice, the infant's actions gradually become more efficient and automatic, eventually permitting the child to think about as well as act on these objects and entities and, still later, integrate information about their dimensions, features, and qualities to solve problems.

KEY THEME
Nature/Nurture

Beyond infancy, the increasing efficiency of cognitive *operations,* processes such as identifying stimuli and recognizing relationships among them, paves the way for greater memory capacity. If children expend a substantial amount of mental effort on identifying or recognizing stimuli, fewer resources will be available for storage and retention of information. Conversely, as children become more proficient at identifying letters, colors, and other features of stimuli, they will have more resources available for remembering. A simple experiment illustrates how these principles work. Three- and six-year-olds were asked to repeat a list of words one at a time as rapidly as possible and then recall that same list of words. Children who were quick to repeat the words had better memory scores than children who were slower at repetition (Case, Kurland, & Goldberg, 1982). As operational efficiency increased with development, more cognitive resources were available for remembering.

According to Case, increases in children's ability to process information quickly are tied to maturational changes in the nervous system as well as to practice with various cognitive activities. One important physiological change that occurs through adolescence is the *myelinization* of areas of the cortex that control alertness and higher-order thinking processes; portions of some neurons develop a fatty coating that speeds neural transmission (Yakovlev & Lecours, 1967). It is plausible that this process is related to the increasing speed of cognitive processing. Practice also helps. In contrast to Piaget, Case allowed a greater role for experience in pushing the child's abilities forward. The more times the child identifies numbers, words, or other stimuli, the more facile she or he will become in this activity. As a result of practice and experience, children develop *central conceptual structures* that guide their performance in specific domains, such as numerical or spatial reasoning. As you will see in the chapter titled "Cognition: Information Processing," many of the ideas Case proposed draw from another theoretical school of cognitive development: the information-processing perspective.

KEY THEME
Interaction Among Domains

FOR YOUR REVIEW

- What are the infant's chief accomplishments during the sensorimotor stage? What is the primary basis of thought in this stage?
- What are the major characteristics of thinking in the preoperational stage?
- What are the major features of thinking in the concrete operational stage?
- What are the major characteristics of thinking in the formal operational stage?
- What are the implications of Piaget's theory for education?
- What are the most important criticisms of Piaget's theory? What research evidence supports these criticisms?
- What are the basic elements of neo-Piagetian approaches to cognitive development?

Concept Development

When and how does the child begin to understand that horses, dogs, and cats all belong to a common category called "animals"? When does she realize that numbers such as "2" or "4" represent specific quantities, no matter what objects are being counted? And how does she mentally organize her spatial environment, such as the layout of her house or the path from home to school? In each case, we are concerned with the ways the child organizes a set of information about the world, using some general or abstract principle as the basis for that organization. In other words, we are describing the child's use of **concepts.**

As one psychologist put it, "Concepts and categories serve as the building blocks for human thought and behavior" (Medin, 1989). Concepts allow us to group isolated pieces of information on the basis of common themes or properties. The result is greater efficiency in cognitive processing. Suppose someone tells you, "A quarf is an animal." Without even seeing one, you already know many of the quarf's properties: it breathes, eats, locomotes, and so on. Because concepts are linked to one of the most powerful human capabilities—language—as well as other aspects of cognition, understanding how concepts develop is an important concern of developmental psychologists. Many modern-day accounts of concept development arose out of attempts to test or expand the groundbreaking ideas Piaget set forth concerning children's understanding of objects, classes of objects, number, and space.

Properties of Objects

The most fundamental early concepts, of course, have to do with the objects infants and young children encounter. What exactly do they understand about the properties of objects, for example, the fact of their continual existence or how one object might cause another to launch forward or zigzag across the room?

● **The Object Concept** We already discussed how Piaget believed that significant accomplishments such as the object concept emerge late in the first year of life and do not become fully elaborated until the second year. We have also seen that experiments such as those of Renée Baillargeon suggest that by three to four months of age, infants may understand far more about the properties of physical objects, such as the object concept, than Piaget surmised (Baillargeon, 1987a; Baillargeon & DeVos, 1991).

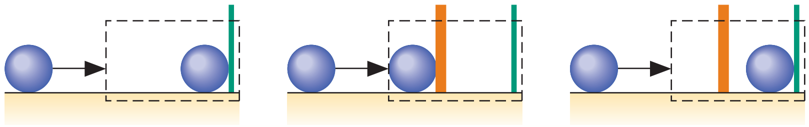
According to Baillargeon, such young infants not only understand that objects exist when out of sight but also understand that the objects' size continues to be preserved as well (Baillargeon, 1987b). In a series of experiments involving the rotation of a screen similar to that shown in Figure 8.2, the rectangular box was either upright (as shown in the figure) or lying flat. Three- and four-month-olds seemed to understand that the screen could not rotate as far when the box was in the upright position as it could when lying down. Moreover, if the object was something that could be squeezed, such as a ball of gauze the infants had previously played with, they were not surprised by the continued rotation of the screen in front of it. They did show surprise when the screen seemed to rotate past the position of a hard and rigid box. Apparently, young infants quickly move beyond simply understanding that an object exists under a cover or behind a barrier; they also develop ideas about physical properties of objects such as their height and rigidity (Baillargeon, 1995).

Similarly, experiments by Elizabeth Spelke and her colleagues show that infants seem to appreciate the concept of *solidity,* the fact that one object cannot pass through the space occupied by another object. In one study, represented in Figure 8.3, two-and-a-half-month-old infants saw a ball roll across a ramp and behind a screen for several trials. Next they saw the ball roll as a partially visible box blocked its path. When the screen was removed, infants viewed the ball either resting in front of the box or at the end of the ramp. Infants looked significantly longer at the impossible result, the ball at the end of the ramp, suggesting to Spelke that infants recognize the concept of solidity. Some of Spelke's other experiments imply that young infants also understand the principle of *continuity,* the idea that objects move continuously in time and space (Spelke et al., 1992).

The results of the violation-of-expectation experiments have led some researchers to formulate the **core knowledge hypothesis,** the idea that young infants possess innate knowledge concerning important fundamental properties of objects (Baillargeon,

concept Definition of a set of information on the basis of some general or abstract principle.

core knowledge hypothesis The idea that infants possess innate knowledge of certain properties of objects.



Source: Spelke et al., 1992.

FIGURE 8.3
Infants' Concepts of Solidity

In an experiment conducted by Elizabeth Spelke and her colleagues, two-and-a-half-month-old infants were habituated to the scene on the left, a ball rolling across a ramp. In the test phase, infants saw events that were either consistent or inconsistent with the principle that one object cannot pass through the space occupied by another. The infants looked longer at the inconsistent event, leading Spelke and her colleagues to postulate that this early knowledge about objects is innate.

2001; Spelke & Hespos, 2001). The implication is that even young infants possess a startling degree of competence as they encounter items and events in the world. Core knowledge becomes elaborated with experience, according to these theorists, but the infant starts out with much more capability than Piaget presumed. There are some problematic findings for those in this camp, however. For example, Neil Berthier and his colleagues (Berthier et al., 2000) had two- and three-year-olds participate in a task similar to the one shown in Figure 8.3. In this case, however, the researchers asked the children to retrieve the ball from behind one of several doors positioned in front or in back of the wall. Children under age three performed poorly; they did not open the door right in front of the wall. If infants have early knowledge of the concept of solidity and can represent hidden objects, why would children several years older fail to locate the object? At the very least, the findings suggest that a great deal of knowledge about the locations of objects develops in the first three years (Butler, Berthier, & Clifton, 2002).

KEY THEME
Nature/Nurture

The contrasting point of view is that infants' performance in the violation-of-expectation tasks is not due to innate core knowledge but rather to perceptual and memory processes that detect that "something is different" or "something is familiar" (Bogartz, Shinskey, & Schilling, 2000). It is wrong, say the critics, to imbue young infants with more advanced or specialized cognitive and representational skills than is warranted (Haith, 1998; Smith, 1999). Rather, it is better to assume that basic, general cognitive processes are responsible for the behaviors we observe. Knowledge about objects is built, say many of these theorists, through rapid advances in attention and memory abilities, as well as the child's experiences in the world. Experts hope that well-designed experiments that rule out competing explanations will help to resolve this controversy (Aslin, 2000).

Given the behaviors of young infants in the violation-of-expectation tasks, why do they fail to retrieve a covered object prior to eight months of age? One possibility is that infants do not yet have the skill to solve means-ends tasks, that is, to develop and execute a plan to reach for and uncover the hidden object. However, seven-month-old infants will pull down a transparent screen to reach for an object behind it; they do not make this response when the screen is opaque (Shinskey & Munakata, 2001). Seven-month-olds can also push a button to make a shelf drop and deliver a visible toy; they do not push the button if the toy is invisible or if button-pushing simply lights a set of lights on the shelf (Munakata et al., 2002; Munakata et al., 1997). A means-ends deficit cannot account for such results, as, under some circumstances, we see that infants can put into action a sequence of steps in order to obtain an object. Yuko Munakata and her colleagues hypothesize that infants' representations of hidden objects are weaker than for visible objects and thus make search tasks more demanding (Munakata et al., 1997). As infants have more experiences in the world, however, and the neural networks that underlie representations of objects become strengthened, children become more successful in retrieving hidden objects (Munakata, 2001).

The A-Not-B Error A common error that occurs when the child is about seven to nine months of age is the A$\overline{\text{B}}$ (or "A-not-B") error. In this task, an object is hidden in location A, found by the infant, and then, in full view of the infant, moved to location B. Piaget observed that the child would mistakenly but persistently search for the object in location A. He hypothesized that the infant's incomplete knowledge

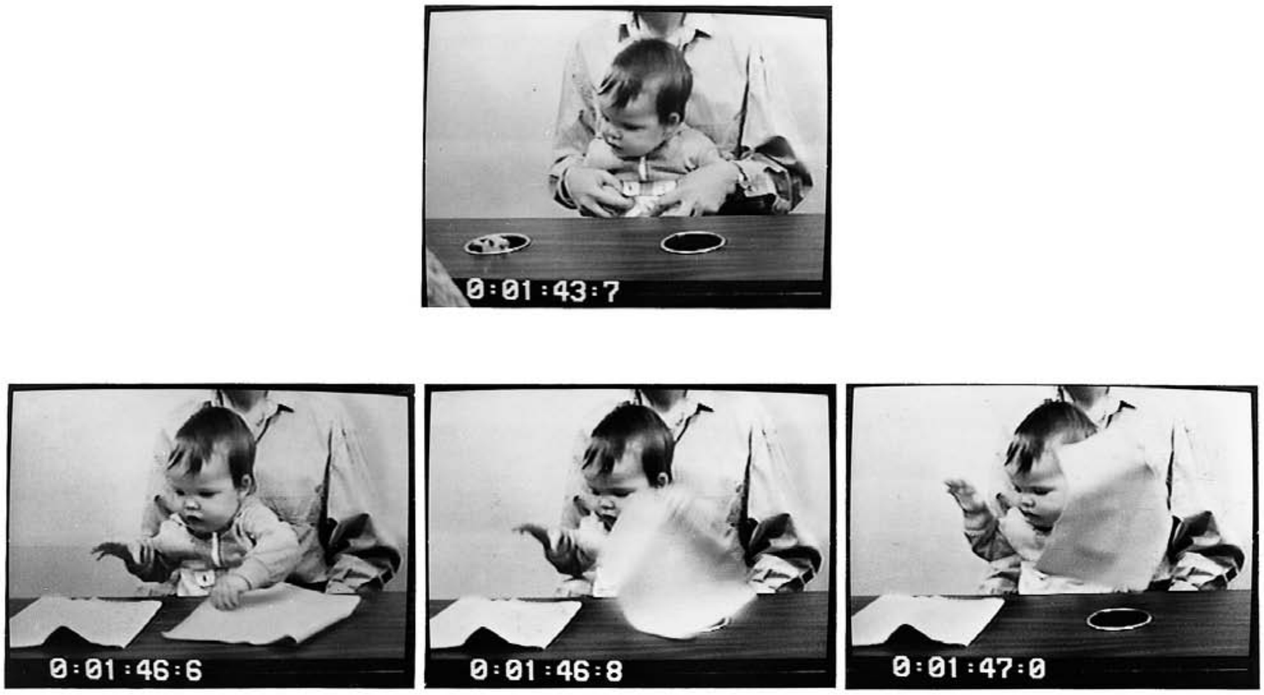


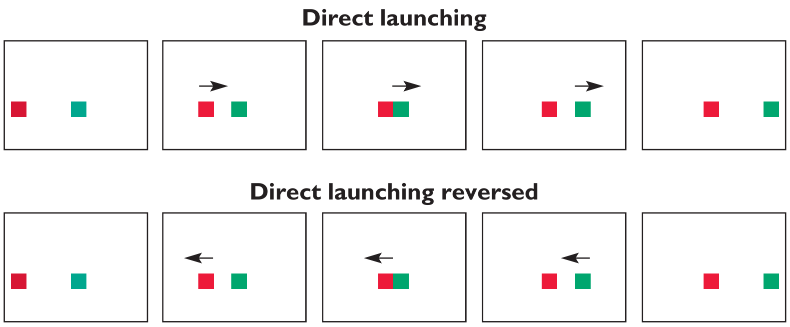
FIGURE 8.4
Alternative Explanations for the A$\overline{B}$ Error

A toy has been hidden first in the right well (location A), then is placed in the well on the left (location B) as shown in the first photograph. The next three photographs show that after the object is hidden, the infant reaches for location A even though he looks persistently at location B. The looking behavior suggests that he has the object concept when there are visible displacements of the object. Diamond (1991) believes that one reason infants reach for the incorrect location is because they fail to inhibit motor responses.

of the object concept leads to this error, in large part because the sensorimotor scheme for searching in location A still controls the child's thought. Researchers, however, have generated several alternative hypotheses about the reasons for the A-not-B error.

For one thing, memory difficulties may play a role. Eight- to twelve-month-old infants are less likely to make the A$\overline{B}$ error when they can search for the object at B immediately as opposed to after a delay. In addition, when watching infants make the A$\overline{B}$ error, Adele Diamond noticed that even though some infants mistakenly *reached* for A, they actually *looked* at B, the correct location of the hidden toy (see Figure 8.4) (Diamond, 1985). They behaved as though they knew the correct location of the toy but could not stop themselves from reaching to A. In other studies, adult monkeys, which normally perform successfully on the A$\overline{B}$ task, make mistakes identical to those of seven-to-nine-month-old human infants when lesions are made in very specific areas of their frontal cortex; these are the brain areas that control the inhibition of responses (Diamond & Goldman-Rakic, 1989). Diamond (1991) proposes that infants have the object concept well before age seven months but, due to the physical immaturity of this special cortical area, they cannot suppress their tendency to reach for location A. Lending support to this hypothesis are data showing that infants who are successful in the A$\overline{B}$ task display more powerful brain electrical activity from the same frontal region of the cortex (Bell & Fox, 1992). Moreover, when infants' responses to the A$\overline{B}$ situation are assessed using the habituation procedure rather than by the child's motor response, they look longer at an impossible event (a toy moves from A to B and is then found at A) than at a possible event (a toy moves from A to B and is found at B) (Ahmed & Ruffman, 1998). Thus infants seem to know the correct location of the transposed object but do not show this knowledge when tasks require reaching.

Another account of the A$\overline{B}$ error states that infants may not be able to efficiently update their representation of the object's location after it is moved to B; in fact, they perform better when the A and B locations are covered with distinctive shapes and colors (Bremner & Bryant, 2001). Perhaps the most comprehensive description comes from a dynamic systems perspective. In this view, the infant's errors arise from competing tendencies of different strengths: the strong memory of the object at A and a deteriorating plan to look at location B in the face of few perceptual cues



Source: Leslie & Keeble, 1987.

FIGURE 8.5
A Demonstration of Infant Discrimination of Physical Causality

In Leslie's experiment, six-month-old infants viewed stimulus sequences that occurred under different conditions. The top row shows a red brick moving and touching a green brick, after which the green brick moves. Infants habituated to this sequence showed dishabituation when the reverse sequence, the green brick moving and striking the red brick, was shown (view the direct launching condition in the figure from right to left); that is, they noticed when the object causing the physical movement switched. In another condition, the red brick moved and touched the green brick, but the green brick moved only after a delay; that is, the cues did not suggest the red brick was causing the green brick to move. Infants habituated to this latter sequence showed less dishabituation to the reversal.

(Smith et al., 1999; Spencer, Smith, & Thelen, 2001). Any of several factors can improve performance: better memory for spatial locations, stronger perceptual cues about the object's location, or heightened attention to the events in the task. As you can see, we now have several alternatives to Piaget's notion that the object concept relies on an internal sensorimotor-based scheme, all of them emphasizing changes in the ability of infants to process information.

Physical Causality Imagine the following scene: a red brick moves halfway across a screen, hits a green brick, and the green brick moves across the rest of the screen. Most adults would conclude that the red brick caused the green brick to glide across the screen. They would not reach that conclusion, however, if they saw that the bricks did not touch each other or if there was a pause between the time the two bricks made contact and the time the green brick started to move (Michotte, 1963).

In a series of experiments, Alan Leslie showed that infants as young as six months exhibit similar reactions (Leslie, 1982, 1984; Leslie & Keeble, 1987). In one condition, infants observed one object collide with another object and propel it forward for a series of trials. After they showed habituation to this scene, they viewed the reverse situation, in which the second object hit and launched the first. Infants showed dishabituation; that is, they treated the two event sequences (depicted in Figure 8.5) as though they were different. In a control condition, infants were habituated to the same events, but the second object moved only after a delay. Now, though, when the event was reversed, little dishabituation was observed. These experiments showed that infants notice something unique about causal events, a result, says Leslie, of an innate propensity to perceive causality. Other research has demonstrated that for infants to react to physical causality, the same objects must be used repeatedly during habituation trials. Reactions to physical causality diminish when the objects themselves change from trial to trial or when the objects are more complex (Cohen & Oakes, 1993; Oakes, 1994; Oakes & Cohen, 1990). In this view, the infant's conceptual understanding of physical causality develops as a result of repeated experiences with specific, simple objects rather because of an innate "causality" module.

Of course, the infant studies just described do not suggest a full-blown appreciation of the concept of causality; they simply imply that before age one year, infants notice something unique about contiguous event sequences in which one object seems to "cause" another to do something. How do slightly older children—preschoolers—understand concepts of causality?

Piaget (1930, 1974) believed that up until the early school years, ages seven or eight years, children lack an awareness of physical causality. Once they are verbal and can discuss causality, they make some interesting errors. One type of error is **animism,** attributing lifelike properties to inanimate objects. In one of Piaget's examples of animism, a six-year-old boy named Vern was asked why a boat floats on water but a little stone sinks. Vern answered, "The boat is more intelligent than the stone" (Piaget, 1929, p. 223). Another child, age seven, is asked if the sun can do whatever it likes. The child responds affirmatively; asked why the sun doesn't stop

animism Attribution of lifelike qualities to inanimate objects.

giving light, the child says, "It wants it to be fine weather" (Piaget, 1929, p. 227). Animism is often accompanied by **artificialism,** the belief that people cause naturally occurring events. Piaget provides the example of a six-year-old named Hub:

Piaget: Has the sun always been there?
Hub: No, it began.
Piaget: How?
Hub: With fire . . . .
Piaget: How did that start?
Hub: With a match . . . .
Piaget: Who struck it?
Hub: A man. (Piaget, 1929, p. 266)

In Piaget's view, children are slow to shed their animistic and artificial beliefs; the latter may persist until age ten years or so (Piaget, 1929).

Susan Gelman and Kathleen Kremer (1991) attempted to replicate some of Piaget's studies by asking preschoolers, "Do you think people made (or make)——?" in which the blank was filled in by an object such as the sun, the moon, dogs, flowers, dolls, and shoes. Few of the children showed evidence of artificialism; most recognized that objects such as dolls are made by humans, but the sun and moon are not. Moreover, these young children often cited natural causes for the behaviors of living things (e.g., birds fly because they have wings) and human causes for the things artificial objects do (e.g., cars go uphill because people make them do so). Why the discrepancy from Piaget's observations? Gelman and Kremer (1991) postulate that direct questions, such as the ones they used, were more likely to tap children's underlying knowledge of causality than the free-ranging interview questions Piaget employed.

Classification

Aside from learning about the properties of single objects, as in the object concept, children also quickly learn about relationships that can exist among sets of objects. Sometimes objects resemble one another perceptually and seem to "go together" because they are the same color or shape. At other times, the relationships among objects can be more complex; the perceptual similarities may be less obvious and, moreover, some sets can be embedded within others. Cocker spaniels and Great Danes, two different-looking dogs, can be classified together in the group "dogs," and both breeds fit into a larger category of "animals." As with many other cognitive skills, Piaget believed that before age seven years, children's ability to classify objects, particularly in the hierarchical manner of the latter example, is limited. Ask a young child who sees six brown beads and three white beads, all of which are wooden, "Do I have more brown beads or wooden beads?" Chances are the four- or five-year-old will respond, "More brown beads." According to Piaget, preoperational children lack the logical thought structures to permit understanding that some classes can be subsets of others (Piaget, 1952a). Piaget was right in claiming that classification skills undergo changes with development, but the research that followed his work has revealed a far more complex portrait of this cognitive skill.

Early Classification One of the earliest signs of classification skills in young children occurs toward the end of the first year, when children begin to group *perceptually similar* objects together. Susan Sugarman (1982, 1983) carefully watched the behaviors of one- to three-year-olds as they played with successive sets of stimuli that could be grouped into two classes, such as plates and square blocks or dolls and boats. Even the youngest children displayed a spontaneous tendency to group similar-looking objects together by pointing consecutively to items that were alike. With the habituation paradigm, it has also been possible to show that three- and four-month-old infants respond to different items, such as dogs, cats, and horses, on the basis of

artificialism Belief that naturally occurring events are caused by people.

perceptual similarity (Oakes, Coppage, & Dingel, 1997; Quinn, Eimas, & Rosenkranz, 1993). Thus the tendency to group objects together on the basis of shared perceptual characteristics emerges early in development.

Between ages one and three years, children experience a rapid growth in classification skills. Infants as young as fourteen months successively touch objects that appear in common contexts, such as "kitchen things" and "bathroom things" (Mandler, Fivush, & Reznick, 1987). Two-year-olds will match items on the basis of *thematic relations,* clustering items that function together or complement one another, such as a baby bottle and a baby (Markman & Hutchinson, 1984). They will also occasionally classify items *taxonomically,* grouping objects that may not look alike on the basis of some abstract principle, such as a banana with an apple (Ross, 1980). Taxonomic classification is easier for young children when they hear that objects from the same category share the same label even though they may not look very much alike (e.g., a panther and a tabby house cat are both called "cats") or when their similarities are pointed out in some other way (Deák & Bauer, 1996; Nazzi & Gopnik, 2001).

In fact, mothers often provide varied information of this sort to their young children about objects and their membership in categories, saying such things as, "That's a desk. That's a desk, too," or pointing sequentially to objects that come from the same conceptual group (Gelman et al., 1998). As children encounter new instances of a category, they incorporate information about those examples into their prior knowledge about the category (Carmichael & Hayes, 2001). As children grow older, they become capable of using a wider range of relations to classify objects, their exclusive reliance on shared perceptual features lessens, and they display spontaneous hierarchical knowledge of categories.

Basic-Level Categories Some groupings of objects can be described as *basic level;* that is, objects go together when they look alike and can be used in similar ways, and when we can think of "average" members of the class. "Chair" is an example of a basic-level concept because virtually all chairs have seats, legs, and backs; all are used for sitting; and we can think of such a thing as a "typical" chair. In contrast, other concepts are *superordinate level.* Members of superordinate-level groups, such as "furniture," do not necessarily share many perceptual attributes, and they are broader and more general than basic-level concepts. Figure 8.6 illustrates this example of a basic-level and a superordinate-level grouping.

Eleanor Rosch and her colleagues believe that because basic-level groups carry more information, especially perceptual information, than superordinate-level groups, they are easier for children to process. Children under age five years readily put together four pictures of different shoes or four pictures of different cars; that is, they could sort according to basic-level groupings (Rosch et al., 1976). Children in Rosch's study could not, however, proficiently sort on the basis of superordinate category by putting a shoe, shirt, sock, and pants together until they reached age eight or nine years. In fact, other research shows that the ability to sort basic-level stimuli is evident as early as eighteen months of age (Gopnik & Meltzoff, 1992). We also saw in the chapter titled "Language" how many of the child's first words are basic-level terms.

Even though Rosch's theory of basic-level categories has had widespread appeal, there are two important points of contention. First, do children really evidence knowledge and use of superordinate categories later (as opposed to early) in development? Not according to findings by Behl-Chadha (1996), which indicate that three- to four-month-olds can categorize superordinate items when the habituation procedure is used. Second, do children's early categories really rely primarily on perceptual information, as the notion of basic-level concepts suggests? Jean Mandler thinks the answer is no (Mandler, 1997). Consider the items shown in Figure 8.7, which are perceptually similar but belong to two different conceptual categories. A group of seven- to eleven-month-olds was allowed to examine several items from one category, say birds, until they were familiar with them. Then two more objects, a

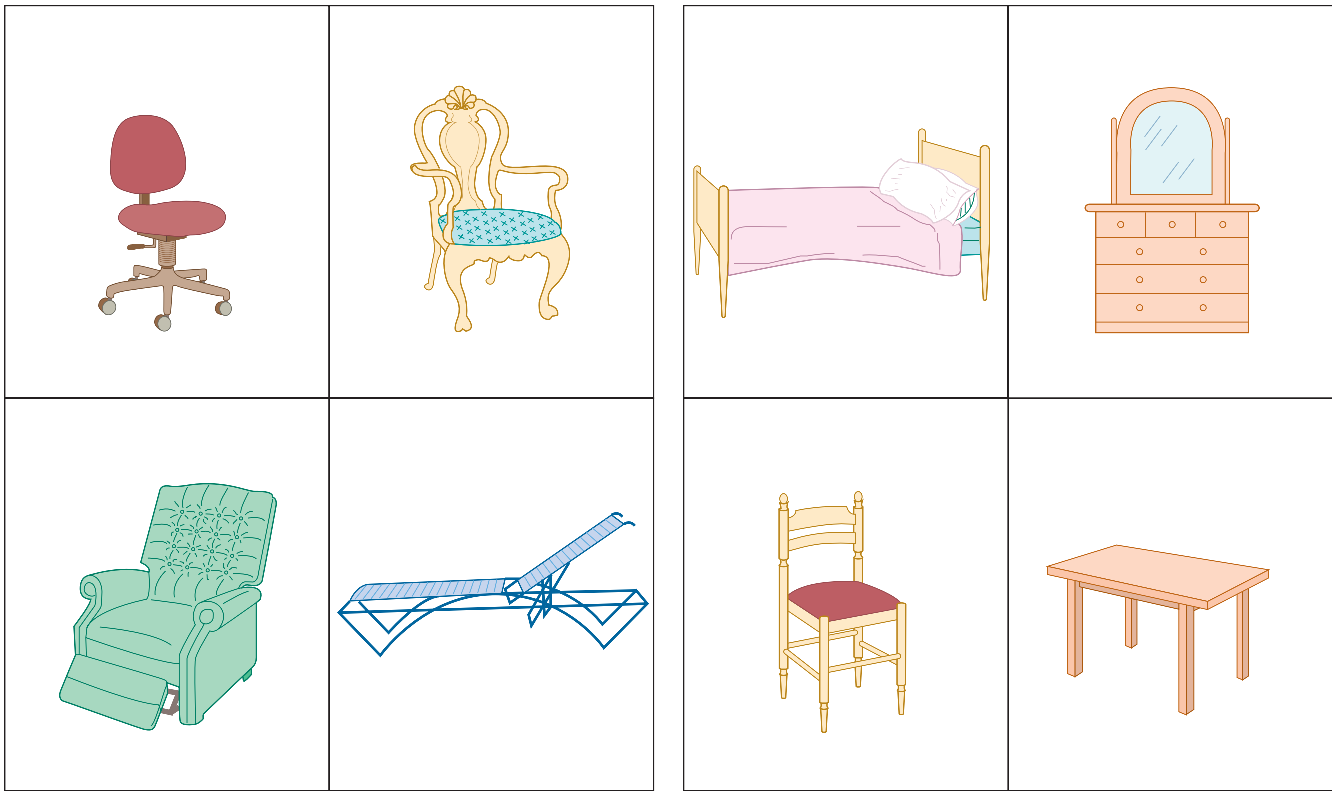


FIGURE 8.6
Basic- and Superordinate-Level Categories

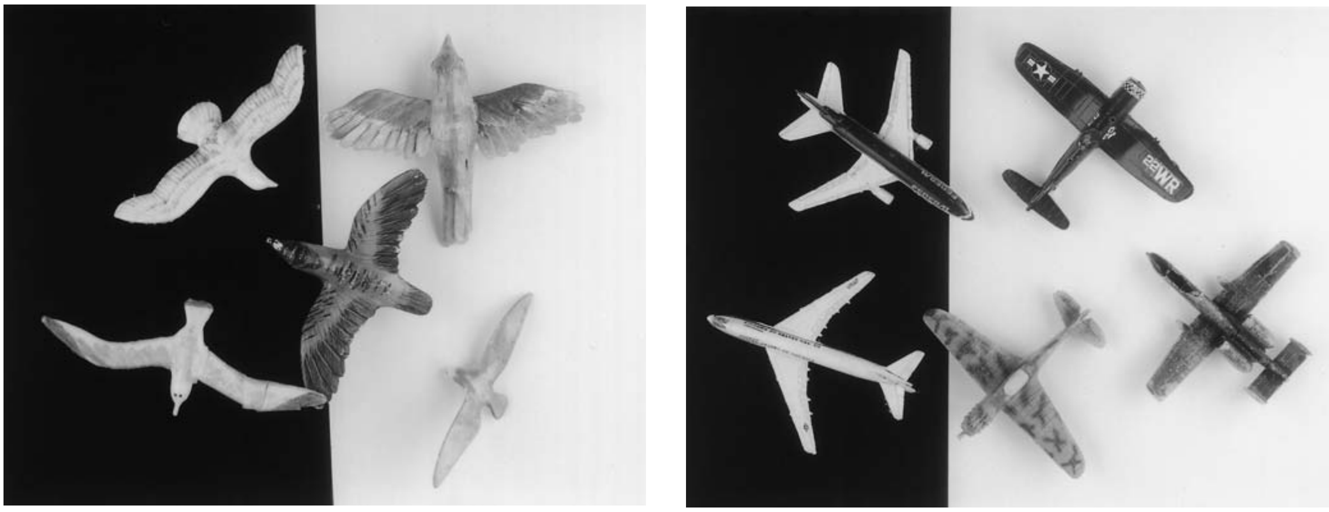
The left panel gives an example of objects that are considered a basic-level grouping. These stimuli share perceptual features, and an "average" member of the class can be conceptualized. The right panel gives an example of superordinate-level grouping. Members of such classes do not necessarily share many perceptual features, and it is more difficult to think of an "average" class member. Basic-level categories are easier for young children to employ than superordinate-level groupings.

new bird and a new plane, were presented. Infants spent more time looking at and manipulating the item from the new category—in this particular instance, planes—than the item from the familiar category despite the striking perceptual similarities between the two groups (Mandler & McDonough, 1993). Mandler argues that infants form categories based on *meanings* rather than perceptual similarities during the latter portion of the first year. Moreover, rather than starting with basic-level categories and progressing to superordinate categories as Rosch has postulated, Mandler and her colleagues maintain that infants begin with broad, general categories. They understand, for example, that different animals (both a dog and a bird) can drink water from a cup but that an airplane cannot. These broad categories of "animalness" become increasingly more fine-tuned and refined with experience (Mandler & McDonough, 1998, 2000).

Natural Domains Recently several developmental psychologists have asserted that some concepts or categories of objects are easier to acquire than others. Just as children seem to be biologically "programmed" to learn language rapidly and easily (see the chapter titled "Language"), so do they seem to learn about certain conceptual domains quickly and effortlessly. In other words, some objects and events in the environment offer "privileged relationships" for the child to learn about (Gallistel et al., 1991). Among these so-called **natural domains** is knowledge about biological entities.

natural domains Concepts or categories that children acquire especially rapidly and effortlessly.

Children show a dramatically early ability to classify animate versus inanimate objects. For example, a twenty-four-month-old will show obvious surprise when a chair seems to move forward on its own (Golinkoff et al., 1984), and a twelve-month-old will fuss and cry more when a robot starts to move as opposed to a human stranger (Poulin-Dubois, Lepage, & Ferland, 1996). Three-year-olds know that living things can feel emotions but inanimate objects cannot; they say a person can feel sad, but a doll or a rock cannot (Gelman, Spelke, & Meck, 1983). Preschoolers also begin to recognize that other processes, such as growth, illness, healing, and death, are unique to biological organisms (Backscheider, Shatz, & Gelman, 1993; Rosengren et al., 1991; Siegal, 1988).



Source: Mandler, 1997.

FIGURE 8.7
How Do Infants Group Birds and Airplanes?

According to research by Mandler and McDonough (1993), seven- to eleven-month-old infants treated these stimuli as belonging to two separate categories, birds and planes, despite the strong perceptual similarities between them. Thus, Mandler argues, infants' categories are based on meanings rather than shared perceptual features.

Part of the usefulness of concepts, of course, is that they permit us to make assumptions about other category members, as in our earlier example of the "quarf." That is, we go beyond the information given, perhaps even beyond the similarities of perceptual features of objects, to make conceptually based judgments or inductions about them. According to Susan Carey (1985b) and Frank Keil (1989), children's inductions are largely guided by "theories" they construct about the nature of specific concepts. For the domain of biological entities, Carey found that children's theories undergo revision with development to allow more and more accurate judgments. For example, a four-year-old who is told that humans have "omenta" will say that only other animals that are very similar to humans also have "omenta." The child's theory about biology centers around what he knows about humans. In contrast, an older child would state that even animals physically dissimilar from humans have "omenta." Her theory of biology extends beyond resemblances to human beings to the broader properties that characterize living things. Theories do seem to play a role in children's categorization. When provided with theories about fictitious animals and their features, for example (e.g., "Wugs are animals that like to fight" and "Gillies are animals that like to hide in trees"), children were more successful in categorizing pictures of "wugs" and "gillies" than when they were trained to focus solely on their features (e.g., "Wugs are animals that have claws") (Krascum & Andrews, 1998).

● **Individual and Cultural Variations in Classification** Implicit in Piagetian ideas about classification is the notion that there should be many similarities in concept development among children, even those from different cultures. However, research suggests that this is not the case. For example, some three-year-olds show a clear propensity to use thematic classification, whereas others prefer taxonomic classification. Interestingly, these individual differences in classification preferences are linked to earlier unique profiles in play and language use. As one-year-olds, "thematic" children have been noted to play with objects in spatial, functional ways and, at age two, use words such as *in* and *down* more than "taxonomic" children do; that is, they have seemingly stable preferences to focus on how objects work in relation to one another (Dunham & Dunham, 1995).

KEY THEME
Individual Differences

Cultural variations in classification occur, too. One group of researchers found that residents of rural Mexico with little formal schooling tended to group objects on the basis of their functional relations. "Chicken" and "egg" were frequently classified together because "the chicken lays eggs." On the other hand, individuals with more education relied on taxonomic classification, grouping "chicken" with "horse" because "they are animals" (Sharp, Cole, & Lave, 1979). It may be that taxonomic classification strategies are taught explicitly in schools or that education fosters the development of more abstract thought, a basic requirement for taxonomic grouping.

KEY THEME
Sociocultural Influence

Any full explanation of the development of classification skills will have to take into account the experiences of children within their specific sociocultural contexts.

Numerical Concepts

Children as young as two years of age frequently use number terms, either to count toys, snacks, or other items or in playful ways, such as shouting, "One, two, three, jump!" as they bounce off their beds (Saxe, Guberman, & Gearhart, 1987). But do young children really understand the full significance of numbers as a tool for establishing quantitative relationships? Or are they merely repeating a series of words they have heard someone else say without fully appreciating the conceptual underpinnings of those words?

Piaget's (1952a) position was that children under age seven years or so, before they enter the concrete operational stage, lack a full grasp of the meaning of numbers. One indication is the failure of preoperational children to succeed in the conservation of number task. In this problem, you will recall, children see two equal rows of objects—say, red and white poker chips—as was shown in Figure 8.1. Initially the rows are aligned identically, and most children will agree that they have equal numbers of chips. But when the chips in one row are spread out, the majority of children state that this row now has more chips even though no chips have been added or subtracted.

Preoperational children, Piaget maintained, fail to comprehend the **one-to-one correspondence** that still exists among items in the two rows; that is, each element in a row can be mapped onto an element in the second row, with none left over. Moreover, he believed young children have not yet attained an understanding of two important aspects of number. The first is **cardinality,** or the total number of elements in a class, as in *six* red poker chips. The second is **ordinality,** the order in which an item appears in the set, as in the *second* poker chip. According to Piaget, the child must grasp both these concepts to judge two sets of items as being equivalent.

Like this four-year-old, many preschoolers are able to count and understand at least some principles of numerical relationships, such as *cardinality*. By claiming that preoperational children do not have a conceptual understanding of number, Piaget probably underestimated children's numerical competence.

one-to-one correspondence Understanding that two sets are equivalent in number if each element in one set can be mapped onto a unique element in the second set with none left over.

cardinality Principle that the last number in a set of counted numbers refers to the number of items in that set.

ordinality Principle that a number refers to an item's order within a set.

Early Number Concepts and Counting Many contemporary researchers believe Piaget underestimated preschool children's understanding of number concepts. For example, two-year-olds will correctly point to a picture with three items, and not a picture with one item, when asked, "Can you show me the three fish?" (Wynn, 1992b). By age four years, many children count—they say number words in sequence and, in so doing, appreciate at least some basic principles of numerical relationships. Rochel Gelman and her associates have argued that young children have knowledge of certain important fundamental principles of counting (Gelman & Gallistel, 1978; Gelman & Meck, 1983). Among these principles are (1) using the same sequence of counting words when counting different sets, (2) employing only one counting word per object, (3) using the last counting word in the set to represent the total number, (4) understanding that any set of objects can be counted, and (5) appreciating that objects can be counted in any order.

When young children count, their words are not devoid of numerical meaning. In one experiment, three- and four-year-olds saw six dolls and five rings and were asked, "There are six dolls. Is there a ring for every doll?" Most of the four-year-olds used number words to answer questions about one-to-one correspondence. For example, many said, "No, because there are six dolls and five rings" (Becker, 1989). In addition, four-year-olds are able to compare quantities, answering correctly such questions as "Which is bigger, five or two?" (Siegler & Robinson, 1982). Thus their understanding of number terms includes relations such as "larger" and "smaller." One interesting pattern, though, is that young children have more difficulty in making such comparisons when the numbers themselves are large (ten versus fourteen) or when the difference between two numbers is small (eight versus nine). The same is true when children have to add, subtract, and perform other calculations with numbers (Levine, Jordan, & Huttenlocher, 1992).

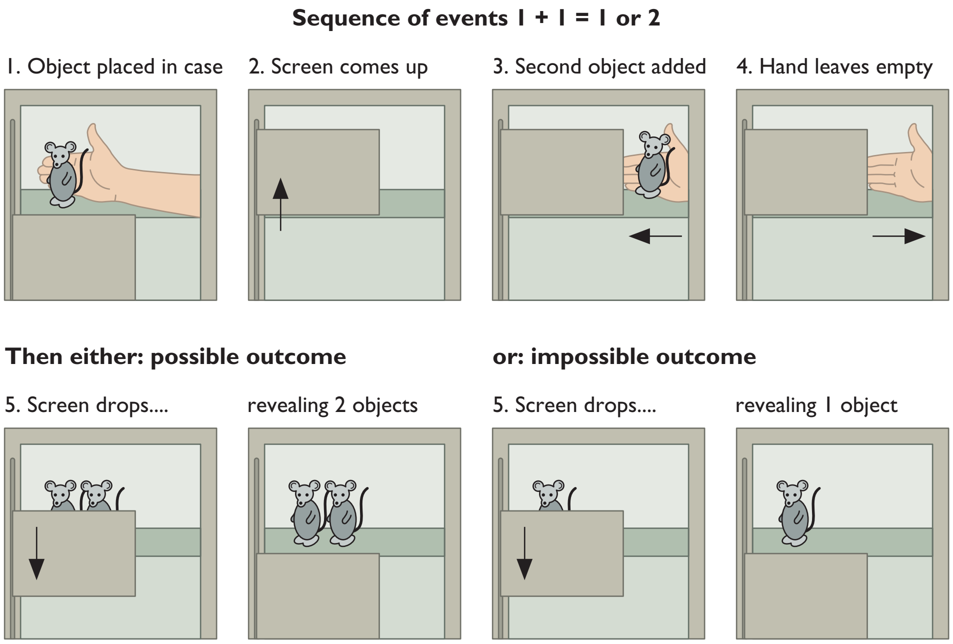
Infants' Responses to Number Thanks to a growing body of research, we now know that even infants demonstrate sensitivity to basic aspects of numerical relationships. Habituation studies show that newborns can detect differences in small numeric sets, such as two versus three (Antell & Keating, 1983) and six-month-olds differentiate between eight and sixteen dots (Xu & Spelke, 2000). Infants even seem to understand something about additive properties of numbers. In one experiment, five-month-old infants watched as a toy was placed in a case and then was hidden by a screen. The infants watched as a second, identical toy was placed behind the screen (see Figure 8.8). When the screen was removed and only one toy remained—an impossible outcome if the infants appreciated that there should still be two toys—they showed surprise and looked longer than they did when two toys were visible (Wynn, 1992a). Other researchers have confirmed that before age six months, babies show numerical competencies that likely serve as the foundation for more complex reasoning about quantities (Canfield & Smith, 1996; Simon, Hespos, & Rochat, 1995).

But what exactly is the nature of those competencies? The preceding findings raise several interesting questions about the processes that underlie infants' behaviors. First, is sensitivity to number another example of innate core knowledge? To some researchers, the answer is yes, especially because infants only five months old appear to be sensitive to addition and subtraction events (Wynn, 1998). Others disagree and point out that the infants in these experiments might be responding on the basis of changes in the visual display other than number. For example, when stimulus items change in number, they also change in the amount of contour, or exterior boundary length, they contain; two mouse dolls have more total "outline" than one mouse doll. In a study in which the stimuli varied *either* in contour length or number, infants responded on the basis of contour length rather than number (Clearfield & Mix, 1999). Similarly, infants respond to changes in surface area of stimuli as opposed to their number (Clearfield & Mix, 2001). Thus it may be more accurate to say that infants respond on the basis of the *amount* of things rather than the *number* of things (Mix, Huttenlocher, & Levine, 2002).

KEY THEME
Nature/Nurture

FIGURE 8.8
Can Infants Add?

This figure shows the sequence of events used in Wynn's (1992a) experiments with five-month-olds. Infants first saw a hand place a mouse doll in the display. Next, a screen rotated up to hide the doll. A hand appeared with a second doll, placing it behind the screen and leaving the display empty-handed. During the test, the screen dropped down and revealed either two dolls (possible event) or one doll (impossible event). Infants looked longer at the impossible event, suggesting they knew something about the additive properties of numbers.

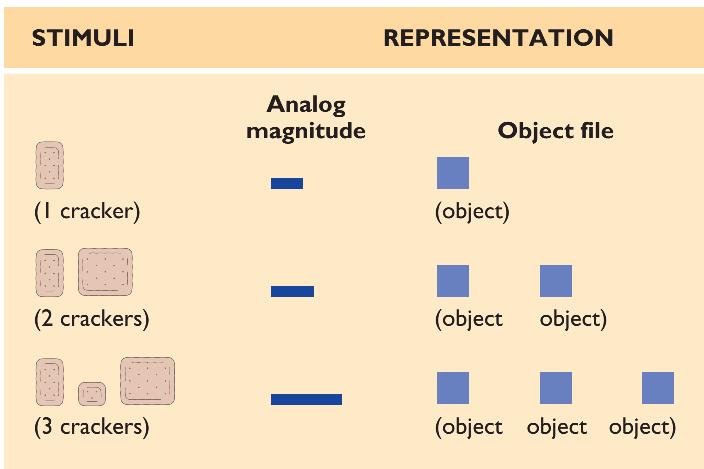


Source: Adapted from Wynn, 1992a.

Second, what is the nature of the representations that subserve infants' responses to number? Figure 8.9 presents two possibilities. One is the *analog magnitude* model, in which the representation consists of a general amount in proportion to the actual number of items (Gelman & Cordes, 2001; Whalen, Gallistel, & Gelman, 1999; Wynn, 1998). One item is represented by a small magnitude, two items by a larger magnitude, and so on. These representations are not numerically precise, but they are sufficient to make judgments about how two stimuli compare with one another in quantity. The other is an *object-file* model, in which each item in a set is represented with a file or marker that denotes quantity but not necessarily the properties of the object. Infants are presumed to be limited in the number of object files they can use (Carey, 2001; Feigenson, Carey, & Hauser, 2002). So far, different investigators have claimed to find evidence consistent with each model (Feigenson et al., 2002; Huntley-Fenner & Cannon, 2000). Researchers are eager to find if either of these two accounts, or perhaps some other mechanism, underlies infants' responses to numbers.

FIGURE 8.9
How Do Infants Represent Number?

Researchers currently hypothesize that infants may represent number in one of two ways. In the analog magnitude model, the representation is a general amount in proportion to the actual number. In the object-file model, each item is represented by a marker that denotes quantity.



Source: Feigenson, Carey, & Hauser, 2002.

● **Learning Mathematics** Once children enter school, of course, they are expected to master the formal properties of numbers through mathematics. Lauren Resnick (1986) believes that before children learn the systematic rules for addition, subtraction, algebra, and other mathematical systems, they develop intuitive concepts about how numbers can be manipulated. How would Pitt, one of her seven-year-old participants, add 152 and 149?

> *I would have the two 100's, which equals 200. Then I would have 50 and the 40, which equals 90. So I have 290. Then plus the 9 from 49, and the 2 from the 52 equals 11. And then I add the 90 plus the 11 . . . equals 102. 102? 101. So I put the 200 and the 101, which equals 301.* (p. 164)

All of this came from a young boy who had mastered only first-grade arithmetic!

In fact, children seem to have a good basic grasp of even more complex numerical concepts, such as fractions, by age four. Suppose a preschooler sees three-fourths of a circle hidden by a screen and then one-half of a circle come out from the screen. How much is left behind the screen? A surprising number of four-year-olds can select a picture of one-fourth of a circle from a set of alternatives (Mix, Levine, & Huttenlocher, 1999). In addition, even a brief training session can help young children understand the basic concepts of fractions. When five-year-olds in one study had the opportunity to observe a whole pizza divided among different numbers of recipients, they began to understand that the size of each share of pizza depended on the number of individuals who were going to eat it (Sophian, Garyantes, & Chang, 1997). Given such findings, it is puzzling that many children experience difficulties with mathematics in school. Perhaps, as Resnick suggests, teachers should frame more complex mathematical operations, such as ratios and algebraic expressions, in terms of simple additive properties or other intuitions children have about numbers, at least when they are first being learned (Resnick, 1995; Resnick & Singer, 1993).

Because Asian students score significantly higher than students from the United States on tests of mathematics (Fuligni & Stevenson, 1995; Geary et al., 1993; Stevenson, Chen, & Lee, 1993), examining the source of their mathematical proficiency can be especially instructive. Asian children use different strategies to solve mathematics problems than American children usually do. Korean and Japanese children, for example, add the numbers 8 + 6 by first trying to reach 10; that is, they add 8 + 2 to make 10 and then add the difference between 6 and 2 to reach the answer, 14. It is interesting to note that in these Asian languages, names for numbers in the teens are "ten one" (eleven), "ten two" (twelve), and so on. Thus children may be used to thinking in terms of tens. Addition and subtraction strategies based on a system of tens are also taught explicitly in Korea and Japan (Fuson & Kwon, 1992; Naito & Miura, 2001); as amount of schooling increases, so does children's use of the base ten approach (Naito & Miura, 2001). Findings such as these offer interesting potential ways of enhancing children's already sound mathematical understanding.

KEY THEME
Sociocultural Influence

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Tests of Math Skills

Spatial Relationships

From early infancy onward, children organize the objects in their world in still another way: according to relationships in space. Where does the toddler find his shoes or an enticing snack? Usually the infant and the young child have developed a mental picture of their homes and other familiar physical spaces to guide their search for missing objects or to reach a desired location. For the older child, spatial understanding extends to finding her way to school, grandparents' homes, or other, more remote locations. As he did for many other areas of cognitive development, Piaget set forth some of the first hypotheses about the child's concepts of space, ideas that later researchers have modified or enriched.

During infancy, Piaget (1954) stated, the child's knowledge of space is based on her sensorimotor activities within that space. For example, the child searches for objects by using *egocentric* frames of reference. That is, if a ball disappears under a couch or chair, the infant represents its location in relation to her own body ("to the left of my arm") rather than in relation to some other external object ("to the left of the door"). Only with the advent of symbolic ability at the end of the sensorimotor stage are children able to use frames of reference external to the self.

Early Spatial Concepts Many researchers have confirmed that children, in the absence of environmental cues, indeed rely on the positions of their own bodies in space to locate objects. For example, in one study, nine-month-olds readily learned to locate an item hidden under one of two covers situated to either their left or their right. Shifted to the opposite side of the table, however, they looked in the wrong location because of their egocentric responding (Bremner & Bryant, 1977). When the investigator made the covers of the two hiding locations of distinctively different colors, infants were able to locate the hidden toy even when they were moved to a different position around the table (Bremner, 1978). Thus infants are not egocentric when other information is available to assist them in finding objects.

Toward the end of the year, children quite literally reach out into the world for cues denoting spatial relationships. Infants slightly under nine months of age use **landmarks** denoting the physical locations of objects to find them in larger spatial environments. When playing peekaboo, infants in one study were assisted in locating a face by different colored lanterns positioned by the correct window, even if their own positions were shifted (Lew, Bremner, & Lefkovitch, 2000). Linda Acredolo and her colleagues demonstrated this skill among older children. Three- through eight-year-olds were taken on a walk through an unfamiliar building in one of two conditions (Acredolo, Pick, & Olsen, 1975). In the first condition, the hallway through which the experimenter led each child contained two chairs; in the second, there were no chairs. The children saw the experimenter drop a set of keys during the walk, and in the "landmark" condition this event occurred near one of the chairs. Later, when children were asked to retrieve the keys, performance was best in the "landmark" condition for the preschoolers; older children did well regardless of the experimental condition.

Young children are also able to use distance cues without the benefit of landmarks to search for objects. Janellen Huttenlocher and her colleagues asked children ages sixteen to twenty-four months to find a toy buried in a five-foot-long sandbox that had no distinguishing landmarks. The success rate for these young children was impressively high (Huttenlocher, Newcombe, & Sandberg, 1994). Using the habituation method, this same research team was able to show that five-month-olds reacted when hidden objects unexpectedly reappeared as little as eight inches from their original hiding location in a thirty-inch sandbox (Newcombe, Huttenlocher, & Learmonth, 2000).

Taken together, these findings show that infants have several ways to locate objects in space—referencing their own bodies, using landmarks, and employing distance cues. As with other forms of conceptual knowledge, researchers debate the degree to which this knowledge is innate and specialized versus acquired and due to more general processes. Most agree, though, that infants and young children are far more competent in this domain than Piaget imagined and that they improve these basic skills as they begin to move about in their environments (Newcombe & Huttenlocher, 2000).

Map Reading One of the practical ways in which spatial skills are exercised is in reading maps. From participating in a "treasure hunt" at a birthday party to traveling or learning geography in school, reading maps, at least occasionally, is part of many children's experiences. Making use of a map involves several types of skills, including understanding that the symbols on the page refer to real objects or places, appreciating the scale and alignment of the map in relation to the actual physical space, and, if one is actually navigating, planning an efficient route in order to get from one place to another.

Four-year-olds begin to show an ability to use simple maps to navigate a U-shaped route through a series of rooms (Uttal & Wellman, 1989). However, their skills are limited to maps for which there is a clear one-to-one correspondence between representations on the map (in this case, photographs of stuffed animals) and real objects in each of the rooms (actual stuffed animals). Also, the map must be aligned to match the actual physical space; rotating it to a different orientation presents problems. Map-reading skills improve in the next two years, though, so that by the time they

landmark Distinctive location or cue that the child uses to negotiate or represent a spatial environment.

are six, many children can use a map to plan an efficient route through a large-scale space (Sandberg & Huttenlocher, 2001). However, understanding maps that are not oriented in the same direction as the physical space remains challenging for children through the early school years (Liben & Downs, 1993).

Why do children improve in map reading? One way to answer this question is to see which kinds of experiences improve children's ability to use maps. When experimenters highlight the connection between objects on the map and objects in the physical space by making explicit comparisons, young children's performances improve (Loewenstein & Gentner, 2001). Organizing the spatial relations among objects in the map—by making them into a drawing, for example—helps, too (Uttal et al., 2001). Thus improvements in children's ability to reason about relations among objects are one likely source of better performance. Creating an efficient map route to follow also depends on the emergence of good planning skills. In fact, many of the problem-solving skills we will discuss in the chapter titled "Cognition: Information Processing" are relevant to children's facility with maps.

FOR YOUR REVIEW

- What kind of knowledge do infants display about the properties of objects?
- What is the core knowledge hypothesis? What research findings support this position on infants' conceptual knowledge? What are the criticisms of this point of view?
- What developmental changes have researchers observed in children's classification skills?
- What developmental changes have researchers observed in children's numerical skills? What basic forms of mathematical reasoning do young children display?
- What developmental changes have researchers observed in children's spatial concepts, including map reading?

Understanding Psychological States

Our knowledge extends beyond understanding of physical objects, classes, number, and space. It also includes an awareness of our minds and how they and the minds of others work. How do children understand and judge the motives, feelings, needs, interests, capacities, and thoughts of playmates, siblings, parents, and others? And how and when do children come to understand and reflect on the psychological states of the self? This type of cognition, thinking about the self and its relationship to the social world, is called *social cognition* and is a vital aspect of successful communication and social interaction. In comparison to the world of physical objects and events, thinking about the social world presents unique challenges to the developing child. People may act unpredictably; their feelings and moods, and even their appearances, may shift unexpectedly. Just how children piece together their understanding of social experiences has been the focus of several lines of research. Here too contemporary researchers owe Piaget recognition for his initial efforts to study how children think about thinking.

KEY THEME
Interaction Among Domains

Perspective Taking: Taking the Views of Others

Perspective taking is the ability to put oneself in another person's place, to consider that person's thoughts, feelings, or knowledge. One basic element of perspective taking is understanding what others see. For example, does the child realize that his sister, who is standing across the room, cannot see the brightly colored pictures in the book he is eagerly examining? In 1956, Jean Piaget and Barbel Inhelder published a classic experiment illustrating children's limited knowledge of the visual perspectives of others. Children seated in front of three different papier-mâché mountains (see

perspective taking Ability to take the role of another person and understand what that person is thinking, is feeling, or knows.

FIGURE 8.10
Visual Perspective Taking

How well can children adopt another person's perspective? Piaget asked this question by seating a child at a table (location 1) containing three "mountains" of different size and color, then asking the child how the scene would look to a doll (or another person) seated at other locations (locations 2 and 3) around the table. Piaget found that preschoolers often chose a view similar to their own. More recent research indicates that preschoolers can more successfully accomplish this task when familiar and easily distinguishable scenes are used.

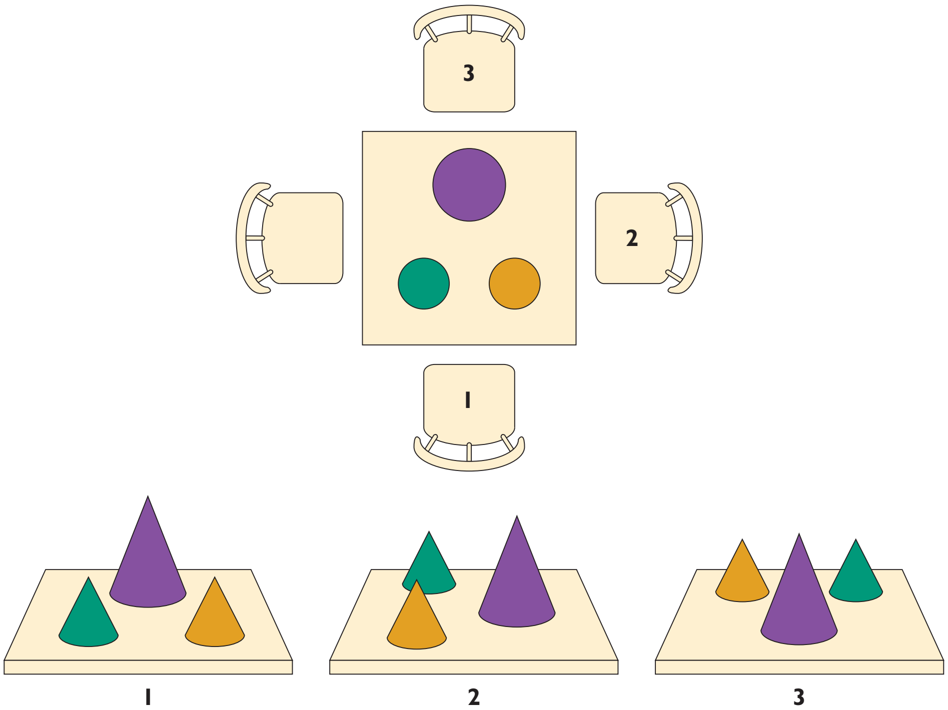

Figure 8.10) were asked to indicate what a doll would see in viewing the array from various locations. Four- to six-year-olds showed considerable *egocentrism* in their responses; they typically indicated that the doll's view would be identical to their own. By six to nine years of age, children began to realize the doll's perspective would differ, although they still had difficulty figuring out what the doll would actually see. Nine- and ten-year-olds were able to determine the doll's perspective accurately. More recent research has shown that the difficulty of the doll and mountain task may have led Piaget and Inhelder to underestimate children's role-taking competence. When simpler visual arrays or familiar everyday scenes are used, or when the method of interviewing children is simplified, three- and four-year-olds can answer some of these kinds of questions reasonably well (Borke, 1975; Newcombe & Huttenlocher, 1992).

Visual perspective taking develops in two phases. At first, from late infancy until about age three years, children come to realize that their own and another's view are not identical. This is called *Level 1 perspective taking*. More advanced *Level 2 perspective taking* appears in three- and four-year-olds and continues to be refined for several years thereafter. Now children can determine the specific limitations of another's view, for example, whether an object or picture another person sees will look right side up or not (Flavell, 1978). These advances reflect cognitive gains in differentiating oneself from another and in knowledge of spatial relationships (Shantz, 1983).

The Child's Theory of Mind

KEY THEME
Interaction Among Domains

Children's understanding of their social world extends beyond visual perspective-taking skills. Emerging among their competencies is an expanding and increasingly coherent appreciation of the kinds of mental qualities that contribute to the behavior of self and others. Did the playmate who broke a favorite toy *intend* to do the damage? Would a close friend *believe* that Mom will not let them go to the park alone? Many of our social behaviors are guided by the judgments and inferences we make about the desires, feeling states, beliefs, and thoughts of other people (Astington, Harris, & Olson, 1988; Slomkowski & Dunn, 1996; Wellman, 1990). In fact, it would be rare *not* to be concerned with the mental states of others in the normal course of interactions with them.

When and how do children become aware of the concept of mental states, their own and those of others? That is, when and how do children develop a **theory of mind**? Once

theory of mind Awareness of the concept of mental states, both one's own and those of others.

again, Piaget has provided much of the impetus for research on this topic. His position was quite clear. As Piaget put it, "The child knows nothing about the nature of thought . . . " (Piaget, 1929, p. 37). Dubbing this characteristic of children **realism,** Piaget maintained that children are not capable of distinguishing between mental and physical entities until the school years. To the child under age eight, dreams and mental images are as real as any event in waking, conscious life. To the same child, thinking is a behavior produced by the body, usually the mouth or the head; physical and mental acts are one and the same.

Understanding Mental States Despite Piaget's strong claims, developmental researchers have uncovered considerable evidence to the contrary. By age three, children readily distinguish between mental and physical entities and, after that age, show further developments in their understanding of their own mental states and those of others (Flavell, 1993).

In one classic experiment, three-year-olds were told stories such as the following: "Judy doesn't have a kitty, but right now she is thinking about a kitty." Could they see or touch the kitty? Could the kitty be seen by someone else or touched at some time in the future? Children had no problem identifying this as a mental event, one in which the kitty could not be seen or touched. In contrast, when they heard other stories, as in "Judy had a kitty," they correctly stated that these real events could be seen and touched (Wellman & Estes, 1986).

Some of the earliest signs of awareness of mental states are evident at eighteen months, when infants follow the gaze of an adult in episodes of joint attention (see the chapter titled "Language"). Infants react to these actions as if the adult "intends" to communicate something (Butler, Caron, & Brooks, 2000). From there, children display an increasing repertoire of knowledge of mental states. Eighteen-month-olds show a beginning appreciation for what it means to "desire" (Repacholi & Gopnik, 1997).Three-year-olds understand the concept of "pretend" or "make-believe" (Harris et al., 1991; Harris & Kavanaugh, 1993), but they still have difficulty with the concept of "belief" (Lillard & Flavell, 1992). Between ages six and ten, children begin to understand "the mind" as an active entity discrete from the self as they interpret metaphors such as "My mind was racing" or "My mind was hungry" (Wellman & Hickling, 1994). At age ten, children also understand that some mental states, such as "wanting" and "fearing," are more difficult to control than others, such as "paying attention" (Flavell & Green, 1999).

False Beliefs A particularly useful scenario to assess aspects of children's theory of mind has been the "false belief" task. Children are shown a doll named Maxi who puts some chocolate in a cupboard and leaves the scene. Maxi's mother moves the chocolate to a new location. When Maxi returns, children are asked, "Where will he look for the chocolate?" Most three-year-olds say in the new location. Four-year-olds, though, recognize that Maxi holds a "false belief" and will look for the chocolate in the cupboard (Wimmer & Perner, 1983).

What factors account for the child's growing success on the false belief task and presumably their theory of mind? Currently there is an ongoing debate. On the one hand, some researchers argue that the theory of mind is an innate, prepackaged, modular form of knowledge that becomes more elaborate as the child's cognitive skills develop (Baron-Cohen, 1995; Fodor, 1992; Leslie, 1994). In support of this view, it is interesting to note that children from several cultures, including China, Japan, and the preliterate Baka society of Cameroon, show similar developmental improvements in their understanding of mental state terms such as "desire" and "belief" (Avis & Harris, 1991; Flavell et al., 1983; Gardner et al., 1988; Tardif & Wellman, 2000). Likewise, performance on the false belief task shows consistent developmental trends across many studies (Wellman, Cross, & Watson, 2001). In contrast, other researchers believe that a theory of mind arises from the child's socialization experiences, especially those that encourage an appreciation of others' mental states. Mothers who use more language to describe mental states to their preschoolers, for example, have children who are more successful on the false belief task several months later (Ruffman, Slade, & Crowe, 2002). Theory of mind may also depend on the extent to which a culture emphasizes this type of

KEY THEME
Nature/Nurture

realism Inability to distinguish between mental and physical entities.

KEY THEME
Sociocultural Influence

understanding. For example, among the Illongot people of the Philippines, there is not a great deal of concern with the concept of mind, so we might not expect to see the emergence of a strong theory of mind (Lillard, 1997, 1998). As you review the child's accomplishments in the Cognitive Development I chronology, you should note that the child's theory of mind, in particular, is a key cognitive attainment bridging the self and social world. Researchers have noted, for example, that performance on the false belief task is related to the child's social skills with peers (Watson et al., 1999). You will encounter several other examples of the link between theory of mind and the child's social and emotional functioning in other chapters.

Atypical Development

Childhood Autism

See For Yourself
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Autism

Childhood autism is a puzzling disorder affecting about one or two of every one thousand children born. The disorder, more common among boys than girls, is characterized by the child's preference to be alone, poor eye contact and general lack of social skills, often the absence of meaningful language, and a preference for sameness and elaborate routines. Some autistic children show unusual skills, such as being able to recite lengthy passages from memory, put together complex jigsaw puzzles, or create intricate drawings. Often these children show a fascination with spinning objects or repeating the speech patterns of someone else. The hallmark trait, though, is the lack of contact these children have with the social world, starting at an early age. Kanner's (1943) description of one autistic boy captures the syndrome well: "He seems almost to draw into his shell and live within himself" (p. 218).

Since Leo Kanner first identified this psychopathology, numerous causes of autism have been proposed, ranging from deprived early emotional relationships with parents to defective neurological wiring in the brain (Waterhouse, Fein, & Modahl, 1996). An intriguing more recent suggestion is that autistic children, for biological reasons, lack the ability to think about mental states; that is, they lack a "theory of mind" that most children begin to develop during the preschool years. Consider how autistic children behave in the "false belief" task described earlier. Whereas most normal four-year-olds are successful, most nine-year-old autistic children fail this problem (Baron-Cohen, Tager-Flusberg, & Cohen, 1993; Frith, 1993). These results suggest that autistic children cannot conceptualize the mental state of another individual. Autistic children, the argument proceeds, have severe deficits in communication and social interaction precisely because they cannot appreciate what the contents of another person's mind might be (Frith & Happé, 1999).

Not all researchers believe the absence of a "theory of mind" explains childhood autism. Some maintain that autistic children cannot disengage their attention from a stimulus on which they are focusing, such as the hiding location in the "false belief" task (Hughes & Russell, 1993). Others suggest that problems with memory or executive control processes are responsible (Bennetto, Pennington, & Rogers, 1996; Carlson, Moses, & Hix, 1998). Moreover, even if autistic children lack a theory of mind, it may not be because of a neurological deficit. Deaf children who are not exposed to sign language for several years, for example, perform similarly to autistic children on the false belief task. Thus, as discussed earlier, the opportunity to engage in conversations from which one might glean information about the mental states of others may be a crucial factor in the development of a theory of mind (Peterson & Siegal, 1999; Woolfe, Want, & Siegal, 2002). Whatever the ultimate basis for autism, however, it seems likely that understanding basic cognitive processes will be helpful in deciphering the mechanisms underlying this perplexing childhood disorder. One outcome of this active area of research, for example, is awareness that autistic children show deficits in joint attention in the preschool years and as early as age one (Dawson et al., 2002; Leekam, Lopez, & Moore, 2000; Osterling & Dawson, 1994), a finding that can be useful in early diagnosis and treatment of this disorder.

FOR YOUR REVIEW

- What developmental changes in visual perspective taking have been identified by researchers?
- What is meant by the child's "theory of mind"? What contrasting positions have been suggested as explanations for the development of theory of mind?
- What is childhood autism? What are some hypotheses about its causes?

Vygotsky's Sociocultural Theory of Cognitive Development

Piaget assumed that cognitive processes function in similar ways across cultures, that the nature and development of thinking have universal qualities. Standing in sharp contrast to these claims are the theoretical ideas of the prominent Russian psychologist Lev Vygotsky (1978). As we saw in the chapter titled "Themes and Theories," Vygotsky wrote that the child's cognitive growth must be understood in the context of the culture in which he or she lives. Vygotsky believed that in formal and informal exchanges with children, caregivers, peers, and tutors cultivate in them the particular skills and abilities their cultural group values. Gradually, regulation and guidance of the child's behavior by others is replaced by internalized self-regulation. Lev Vygotsky made such *social activity* the cornerstone of his theory, which, like Piaget's, has had enormous impact on the field of developmental psychology.

KEY THEME
Sociocultural Influence

Scaffolding

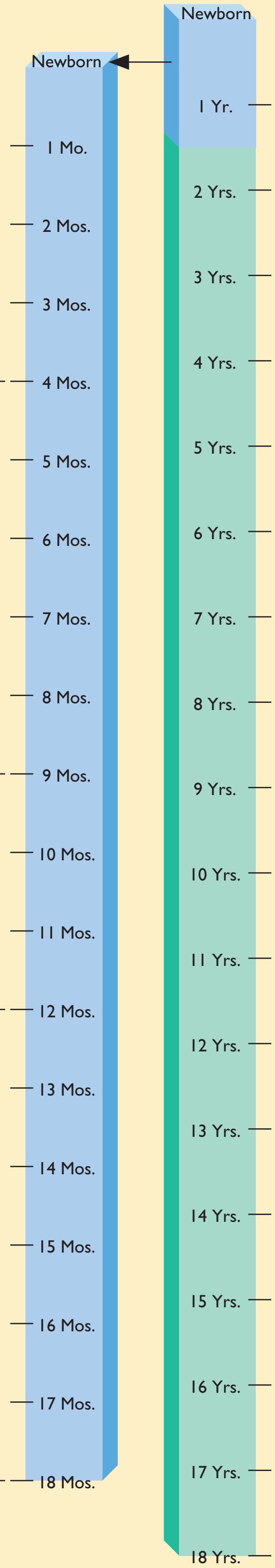
The concept of **scaffolding** is a way of thinking about the social relationship involved in learning from another person (Wood, Bruner, & Ross, 1976). A scaffold is a temporary structure that gives the support necessary to accomplish a task. An effective caregiver or teacher provides such a structure in problem-solving situations, perhaps by defining the activity to be accomplished, demonstrating supporting skills and techniques in which the learner is still deficient, and motivating the beginner to complete the task. The collaboration advances the knowledge and abilities of the apprentice, as illustrated by the following study of a toddler learning to label objects. Anat Ninio and Jerome Bruner (1978) visited the child in his home every two weeks from age eight months to two years. One commonly shared activity they observed was reading from a picture book, with the boy's mother providing the scaffold for the child to learn more about his language.

> *The mother's (often quite unconscious) approach is exquisitely tuned. When the child responds to her "Look!" by looking, she follows immediately with a query. When the child responds to the query with a gesture or a smile, she supplies a label. But as soon as the child shows the ability to vocalize in a way that might indicate a label, she raises the ante. She withholds the label and repeats the query until the child vocalizes, and then she gives the label if the child does not have it fully or correctly.*
>
> *Later, when the child has learned to respond with shorter vocalizations that correspond to words, she no longer accepts an indifferent vocalization. When the child begins producing a recognizable, constant label for an object, she holds out for it. Finally, the child produces appropriate words at the appropriate place in the dialogue. Even then the mother remains tuned to the developing pattern, helping her child recognize labels and make them increasingly accurate.* (Bruner, 1981, pp. 49–50)

Scaffolding involves a teaching/learning relationship that uses the expert or tutor who intervenes as required and gradually withdraws as assistance becomes unnecessary. Patricia Greenfield (1984) observed this phenomenon among girls learning to weave in Zinacantan, Mexico. Beginners, in the presence of at least one expert weaver

scaffolding Temporary aid provided by one person to encourage, support, and assist a lesser-skilled person in carrying out a task or completing a problem. The model provides knowledge and skills that are learned and gradually transferred to the learner.

CHRONOLOGY: *Cognitive Development I*



4–9 Months

- Develops object concept.
- Notices events containing physical causality.
- Shows sensitivity to changes in number.
- Notices changes in distance cues.
- Relies primarily on own body but also on simple landmark cues to locate objects in space.

12–18 Months

- Classifies objects according to physical similarities.

18–30 Months

- Classifies according to thematic and simple taxonomic relations.
- Distinguishes between animate and inanimate objects.
- Understands the meaning of simple number terms.
- Uses distance cues to locate objects.
- Realizes others can have different visual perspectives.

3–4 Years

- Understands basic principles of counting.
- Displays intuitive concepts about numbers.
- Uses landmarks to negotiate spatial environments.
- Uses simple maps to negotiate through space.
- Is aware of specific limitations in visual perspectives of others.
- Understands "pretend" and "make-believe."
- Develops a "theory of mind."

6 Years

- Plans efficient routes with maps.

10 Years

- Can consider own and the perspective of others simultaneously.

This chart describes the sequence of cognitive development based on the findings of research. Children often show individual differences in the exact ages at which they display the various developmental achievements outlined here.

(usually the mother), started by weaving small items and performed only the simpler parts of the task. The more experienced the learner, the less likely the teacher was to intervene to complete the more technically difficult steps. Novices were more likely to receive direct commands from the teachers, whereas experienced weavers were more likely to receive statements or comments. Both verbal and nonverbal assistance declined as the girls became increasingly proficient weavers, although the expert continued to be a role model for both specific techniques and more general principles of weaving. Remarkably, the scaffolding the tutor provided yielded a woven product from beginners indistinguishable from those completed by expert weavers. These examples illustrate what Vygotsky (1978) called the **zone of proximal development,** the span or disparity between what children are able to do without the assistance of others and what they are often able to accomplish by having someone more expert assist them at key points. Vygotsky claimed the most effective assistance from the expert is that just slightly beyond or ahead of the child's current capacities.

Lev Vygotsky (1896–1934), with his sociocultural theory, made substantial contributions to our understanding of cognitive development.

The Role of Skilled Collaborators

As the phenomena of scaffolding and the zone of proximal development suggest, a role model who is sensitive to the learner's level of knowledge contributes greatly to the effective transmission of skills. The effect can be demonstrated in tasks as diverse as the three-year-old's learning to distinguish the colors and shapes of pictures (Diaz, Neal, & Vachio, 1991) to fifth-graders learning how to carry out long division in mathematics assignments (Pratt et al., 1992). Of course, some tutors may be better at these activities than others. Barbara Radziszewska and Barbara Rogoff (1988) examined how nine- and ten-year-olds learned to plan errands. One group of children worked with their parents to organize a shopping trip through an imaginary town, while a second group of children worked with a peer to plan the expedition. Children who worked with adults were exposed to more sophisticated planning strategies; they explored a map of the town more frequently, planned longer sequences of activities, and verbalized more of their plans. Instead of using a step-by-step strategy ("Let's go from this store to the next closest store") as the peer pairs did, children working with adults formulated an integrated sequence of actions ("Let's mark all the stores we have to go to in blue and see what is the best way between them"). In the second part of the experiment, all of the children were observed as they planned a new errand in the same town, this time by themselves. Children who had initially worked with their parents employed more efficient planning strategies than children who had worked with peers.

Why does collaboration with adults work so well? In a follow-up study, Radziszewska and Rogoff (1991) observed that when children worked with adults, they participated in more discussion of the best planning strategy—more "thinking out loud"—than when they worked with peers who had expertise in planning. When working with adults, children were generally more actively involved in the cognitive task, whereas they tended to be more passive observers when their tutor was another child.

Barbara Rogoff and her colleagues (1993) have suggested that the extent to which children and adults take an active role in learning the skills, values, and knowledge of their community differs across cultures. In general, in all communities adults provide a scaffolding for children to begin engaging in mature activities, a process the researchers label *guided participation*. However, children take on a greater burden of responsibility for managing their attention, desire, and interest in mature activities in communities in which they are routinely in the company of adults. The guidance caregivers provide in this context is likely to be in the form of supporting children's observations and efforts rather than in the form of instruction. In contrast, when much of a child's day is spent separate from adults, the child will need more directed lessons and training to acquire mature skills. In this context, the caregivers assume comparatively greater responsibility in helping children to observe and understand the world.

WHAT DO YOU THINK?

Is Home Schooling a Good Idea?
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KEY THEME
Sociocultural Influence

zone of proximal development Range of various kinds of support and assistance provided by an expert (usually an adult) who helps children to carry out activities they currently cannot complete but will later be able to accomplish independently.

By watching skilled collaborators and participating in guided learning, this Afghan boy is learning how to make a basket, an ability that is highly valued in his culture. Vygotsky emphasized the importance of sociocultural context in influencing which skills and abilities will be nurtured among children. Caregivers transmit knowledge by providing children with the *scaffolding* necessary to complete a task, gradually withdrawing as the child gains competence.

Rogoff and her colleagues (1993) found that in communities in India and Guatemala, where young children could watch and enter into adult social and work activities, caregivers were likely to assist and support children in carrying out the more mature responsibilities, such as learning to dress themselves or play with a new toy. On the other hand, in middle-income communities in Turkey and the United States, where children were more likely to be segregated (and parents could not be as consistently attentive and supportive), caregivers were likely to promote play and conversation or provide lessons or learning opportunities in interacting with children to teach them new skills. These interactions, in other words, looked more like the kind typically found with older children in formal school settings. Thus, although all caregivers provided guidance for more mature behavior in each community, its specific form differed, a confirmation of the diverse ways learning may be encouraged in various cultural contexts.

Cognitive development, as you can see, takes place in a distinctly social context, resulting from the child's collaboration with and internalization of social exchanges with parents, peers, and teachers (Rogoff, 1998). An important ingredient in the process of guided participation is the establishment of **intersubjectivity,** the mutual attention and shared communication that take place between expert and learner. We have already seen evidence of intersubjectivity in the chapter titled "Language," in which we discussed how episodes of joint attention contribute to language acquisition. Intersubjectivity is also undoubtedly related to many of the aspects of emotional development discussed in the chapter titled "Emotion" and to the emergence of the child's theory of mind. Infants show the early beginnings of participating in shared attention and communication in the first few months of life in such simple routines as the game of peekaboo (Rochat & Striano, 1999). Researchers are now actively exploring the development of intersubjectivity and how it relates to the various domains of child development.

Developmental psychologists have shown widespread interest in Vygotsky's theory. Many have accepted his claims for the social basis of cognitive development and the importance of understanding the sociocultural context in which the child grows up. Despite the fundamental differences between the ideas of Piaget and Vygotsky, both "theoretical giants" have attempted to capture the dynamism and complexity of how children *develop* in their thinking.

intersubjectivity Mutual attention and shared communication that take place between child and caregiver or learner and expert.

Research Applied to Education

Reciprocal Teaching

Although Craig had always been impressed with Tommy's social skills, he and Marta, his wife, were more concerned with how Tommy was doing in reading in school. Although he could read aloud fairly well, he seemed to have consistent problems in understanding what he read. This was beginning to affect his performance in social studies, science, and other subjects in which students were expected to do quite a bit of independent fact-finding. Tommy seemed to stumble through these assignments and was beginning to feel embarrassed by the grades he was getting. At the last parent-teacher conference, though, Craig and Marta were reassured. The third-grade teacher was trying a new approach to reading called "reciprocal teaching," and she was very encouraged by the visible changes she saw in students' performance and attitudes toward their schoolwork.

Several facets of Vygotsky's theory can be seen in action in a special program developed to foster the emergence of reading comprehension strategies in junior high school students (Brown et al., 1991; Palincsar & Brown, 1984, 1986). The students received instruction in several important reading skills with an instructional method called *reciprocal teaching*. According to this method, teachers should do the following:

1. *Introduce students to four key reading comprehension strategies.* These strategies are summarizing, clarifying word meanings and confusing passages, generating questions about the passage, and predicting what might happen next.

2. *Provide the scaffolding for how to use comprehension strategies.* For one paragraph, the teacher models how to summarize the theme, isolate material that needs to be clarified, anticipate questions, and predict what will happen next.

3. *Ask students to engage in the same four activities for the next paragraph.* The teacher adjusts instructions according to the needs of the individual students, working within what Vygotsky would call each student's *zone of proximal development*. The teacher also provides feedback, praise, hints, and explanations. The teacher invites other students to react to a student's statements, adding other questions, making predictions, or requesting clarification. Teacher and students alternate paragraphs in the early stages of this process.

4. *Become less directive as the students become more skilled in each component of reading.* The students gradually take charge of the process, and the teacher becomes more of an observer, adding suggestions and support when necessary.

Table 8.2 gives an example of the teacher-student exchanges that typically occur with this method.

The results of training were impressive. Whereas during the pretests students averaged 20 percent correct in answering ten questions from reading a paragraph of material, after twenty sessions of reciprocal teaching they averaged 80 percent correct on similar tests. Six months later, students trained in this method moved up from the twentieth percentile in reading ability in their school to the fifty-sixth percentile. Several other studies have documented similar success of reciprocal teaching from as early as first grade (Rosenshine & Meister, 1994).

The key to the success of reciprocal teaching, many experts believe, is the carefully modulated interaction between teacher and students, a point Vygotsky consistently emphasized.

TABLE 8.2
An Example of Reciprocal Teaching

This conversation illustrates the types of exchanges that typify reciprocal teaching. The teacher and, eventually, the students model question asking, summarizing, clarifying, and predicting. In this particular excerpt, students have begun to assume control over their own learning. Students who participated in this program showed significant gains in reading comprehension.

Reciprocal Teaching	
Student 1:	(*Question*) My question is, what does the aquanaut need when he goes under water?
Student 2:	A watch.
Student 3:	Flippers.
Student 4:	A belt.
Student 1:	Those are all good answers.
Teacher:	(*Question*) Nice job! I have a question too. Why does the aquanaut wear a belt? What is so special about it?
Student 3:	It's a heavy belt and keeps him from floating up to the top again.
Teacher:	Good for you.
Student 1:	(*Summary*) For my summary now: This paragraph was about what aquanauts need to take when they go under the water.
Student 5:	(*Summary*) And also about why they need those things.
Student 3:	(*Clarify*) I think we need to clarify gear.
Student 6:	That's the special things they need.
Teacher:	Another word for gear in this story might be equipment, the equipment that makes it easier for the aquanauts to do their job.
Student 1:	I don't think I have a prediction to make.
Teacher:	(*Prediction*) Well, in the story they tell us that there are "many strange and wonderful creatures" that the aquanauts see as they do their work. My prediction is that they'll describe some of these creatures. What are some of the strange creatures you already know about that live in the ocean?
Student 6:	Octopuses.
Student 3:	Whales?
Student 5:	Sharks!

Source: From Palincsar, A. S., & Brown, A. L. (1986, April). Interactive teaching to promote independent learning from text. *The Reading Teacher, 39*(8), 771–777. Reprinted with permission of Annemarie S. Palincsar and the Internation Reading Association.

FOR YOUR REVIEW

- What are the essential elements of Vygotsky's sociocultural theory of development?
- How do the processes of scaffolding, guided participation with skilled collaborators, and intersubjectivity contribute to development?

CHAPTER RECAP

Summary of Developmental Themes

■ **Nature/Nurture** ***What roles do nature and nurture play in cognitive development?***

A central tenet of Piaget's theory is that maturation, in conjunction with experience, is responsible for the child's cognitive growth. Neo-Piagetian theorists echo the same theme. When we examine the child's concept development, we may find that certain natural domains offer the child "privileged relationships" to learn about. The role of nature is implicated here. At the same time, studies of concept formation in different cultures suggest that experiences, like formal schooling, also play a role in determining whether children will display specific kinds of classification skills. The role of experts in guiding the child's development—that is, nurture—is emphasized in Vygotsky's theory.

■ **Sociocultural Influence** ***How does the sociocultural context influence cognitive development?***

Piaget's theory emphasizes the universal cognitive attainments of all children, regardless of their cultural background. However, research has shown that the sociocultural context, the cornerstone of Vygotsky's theory, cannot be ignored. For example, not all children in all cultures attain formal operational thought. We have also seen that children with formal schooling employ taxonomic classification more frequently than unschooled children. Cultural beliefs are often transmitted to children through the scaffolding provided by experts.

■ **Child's Active Role** ***How does the child play an active role in the process of cognitive development?***

A central assumption in Piaget's theory of cognitive development is that the child actively organizes cognitive schemes and knowledge to more effectively adapt to the demands of the environment. In fact, this idea, a hallmark of Piaget's work, is widely accepted by developmental psychologists of different theoretical persuasions. Vygotsky, too, emphasized the active role of the child, in the sense that what the child has learned contributes to the kinds of interactions to which she or he will be exposed.

■ **Continuity/Discontinuity** ***Is cognitive development continuous or discontinuous?***

Piaget stressed stagelike attainments in thinking. Others who have empirically reevaluated his work make claims for more continuous changes in cognition in their focus on the underlying basic processes that contribute to development. Unlike Piaget, Vygotsky did not emphasize discontinuities in development.

■ **Individual Differences** ***How prominent are individual differences in cognitive development?***

Piaget emphasized the common features of thought displayed by all children. His explicit goal was to explain the general characteristics of cognition as children move from the sensorimotor through the formal operational stage of development. Although Piaget acknowledged that some children may reach a given stage earlier or later than others, his main concern was not with individual differences among children. Others, including the neo-Piagetians, argue that children may show greater or lesser abilities within particular domains, depending on the specific experiences to which they are exposed. Thus substantial individual differences in cognitive development may occur among children of similar ages. Finally, Vygotsky argued that children will show differences in development depending on the values of the larger culture and the sensitivity of skilled collaborators to the child's needs in the learning situation.

■ **Interaction Among Domains** ***How does cognitive development interact with development in other domains?***

The child's emergent cognitive skills interact with almost every other aspect of development. For example, children's decreasing cognitive egocentrism will affect their ability to make judgments in perspective-taking tasks, which have important social ramifications. By the same token, development in other domains can influence cognitive growth. For example, cognition may be affected by maturation of the central nervous system, which is hypothesized to contribute to progress in the speed and efficiency of cognitive processing. The child's thinking is thus both the product of and a contributor to development in many other domains.

Summary of Topics

Piaget's Theory of Cognitive Development

- One of the most comprehensive theories of cognitive development was proposed by Jean Piaget. Piaget championed the active role of the child in the construction of knowledge and the transformation of cognitive schemes as a result of maturation combined with experience.
- Piaget believed that children progressed through four stages of development, each with its own unique characteristics.

Stages of Development

- The chief feature of the *sensorimotor stage* is that thought is based on action. Children develop *means-ends behavior,* separate the self from the external environment, and attain the *object concept*. The end of this stage is signaled by the child's ability to engage in deferred imitation, a form of representation.

- Children in the *preoperational stage* can think using symbols, but their thought is limited in that it is *egocentric*. Children fail *conservation tasks* because they do not yet have the logical thought structures that allow them to think about *reversibility*. They also focus on only one aspect of the problem (*centration*), and they tend to *focus on states*.
- The *concrete operational stage* is characterized by logical thought, but only in the presence of real objects or images. Because children are capable of performing *operations*, they are successful on increasingly difficult conservation tasks, as well as seriation tasks.
- By the time children reach the *formal operational stage*, they can think abstractly and *hypothetically*, generating multiple solutions to a problem. Thought is also systematic. Adolescents in this stage may display beliefs in the *imaginary audience* and the *personal fable*.

Implications for Education

- Piaget's theory implies that teachers must take into account the child's current stage of development and supply activities consistent with his or her capabilities.
- Teachers should also be aware of the individual child's current state of knowledge so that new material can be readily assimilated.
- Piagetian theory supports the active role of the child in the educational process.

Evaluating Piaget's Theory

- One criticism of Piaget's theory is that he underestimated the competence of young children. Evidence for the attainment of the object concept by about six months of age, for example, shows that children may not need to gradually build up certain knowledge over time.
- Another criticism is that children's performance may not be as stagelike as Piaget maintained. There is less consistency in the child's behaviors within a stage than the theory claims.
- Some critics maintain that cognitive development is not a general process, but rather shows more rapid advances in some domains than in others. One example is children's early sensitivity to biological entities.
- Researchers have proposed alternative explanations for the behaviors Piaget observed. Some data suggest that changes in information processing lie behind advances in cognition, and other data imply a larger role for the sociocultural environment than Piaget acknowledged.

Neo-Piagetian Approaches

- Theories such as those of Fischer and Case postulate stages of development but allow a greater role for experience and domain-specific accomplishments than did Piaget.

Concept Development

- A *concept* is a set of information defined on the basis of some general or abstract principle. Concepts result in greater efficiency in information processing.

Properties of Objects

- Young infants seem to be sensitive to the height and rigidity of objects, as well as the concept of solidity, leading some researchers to formulate the *core knowledge hypothesis*, the idea that infants possess innate knowledge of certain properties of objects. Others believe that infants' responses to objects are due to information-processing components such as attention and memory.
- Infants display the A-not-B error at about eight to twelve months of age. Explanations of this error include problems in memory, the failure to suppress an already made motor response, and an inability to update information about an object's changed location.
- Infants show an apparent awareness of the concept of physical causality. Older children fail to show the *animism* and *artificialism* described by Piaget when they are asked direct questions about the causes of things.

Classification

- One-year-olds group items together on the basis of perceptual similarities. Slightly older children rely on thematic and taxonomic relations.
- Some researchers believe that children begin to classify with basic-level (perceptually similar) categories and progress to superordinate relations. Others maintain that children's early concepts are global and based on meanings and that they become more refined with development.
- The learning of concepts in *natural domains* occurs at an accelerated pace. Children also seem to form theories about the meanings of concepts, ideas that become more elaborated with development.

Numerical Concepts

- Piaget maintained that preoperational children fail to comprehend *one-to-one correspondence, cardinality,* and *ordinality*. However, by age four, children are able to count, and they display some knowledge of certain numerical principles. Preschoolers understand relations such as "bigger" and "smaller," but have more difficulty with large number sets and numbers that are close together.
- Newborns detect differences in small number sets, and five-month-olds respond to addition and subtraction of objects in a display. Some researchers believe that sensitivity to number is innate, but others say that infants may be responding on the basis of other attributes of the displays. A fundamental question concerns the nature of infants' underlying representations of number.
- Preschoolers display good intuitions about how to add and form fractions. These understandings can form the basis for mathematical instruction.

Spatial Relationships

- Infants first rely on the locations of objects relative to their own bodies, but they can soon use cues such as color as *landmarks* to locate objects in physical space. Infants and young children are also sensitive to distance cues in locating objects.

- Four-year-olds can use simple maps to navigate a route, but map-reading skills improve over the next few years. Children learn to understand that symbols in the map refer to corresponding real-world objects, understand the scale and alignment of the map, and become able to plan an efficient route using the map.

Understanding Psychological States

- A vital aspect of communication and social interaction is the ability to understand the thoughts, feelings, and motives of others.

Perspective Taking: Taking the Views of Others

- Although Piaget believed that preoperational children were limited in the ability to take the visual perspective of others, children show competence when these tasks are simplified or made more familiar. Children first recognize that their view is not identical to that of another person, and then they can determine the specifics of the other's view.

The Child's Theory of Mind

- According to Piaget, preschoolers display *realism,* the failure to distinguish between physical and mental states. More recent research has shown that mental-state knowledge is acquired much earlier than he suspected.
- Children begin to show knowledge of mental states at about eighteen months, when they follow the gaze of another person and show an understanding of the concept of "desire." In the years that follow, children understand concepts such as "pretend," "belief," and other aspects of the mind as an entity.
- Children under age four and autistic children typically fail the false belief task, a test of acquisition of *theory of mind*. Researchers disagree about the source of the child's theory of mind. Some feel that it is an innate, modular form of knowledge, whereas others claim it arises from the child's experiences with language.

Vygotsky's Sociocultural Theory of Cognitive Development

- A principle feature of Vygotsky's theory is that the child's cognitive growth must be understood in terms of the sociocultural context in which he or she lives.

Scaffolding

- Scaffolding is the temporary support provided by an expert to a learner who is trying to accomplish a task. Novice learners often get more support, but as their skills improve, that support is gradually withdrawn.
- Tutors often work within the child's *zone of proximal development,* the distance between what the child can do alone and what she can do with guidance.

The Role of Skilled Collaborators

- Research shows that adults play a critical role in the transmission of skills, probably because they encourage children to be active and to think out loud.
- Some communities may afford children more opportunities for guided participation than others, especially when the children are routinely in the company of adults.
- An important ingredient in the process of guided participation is the establishment of *intersubjectivity,* a state of mutual attention and shared communication.