of the same phenomena but explain their occurrences differently. For example, cognitive change is addressed in all the theories, but the theories have different explanations of the mechanisms that are responsible for the change. Some theories emphasize maturation (nature) as responsible, whereas others emphasize learning (nurture), although each theory acknowledges both factors in interaction as vital to development (see Dixon & Lerner, chap. 1, this volume). Bear in mind this interaction of nature and nurture as you read about the various theoretical perspectives on cognitive development.

THE THEORY OF JEAN PIAGET

No one has equaled the contribution to cognitive-developmental research of Swiss theorist Jean Piaget. Piaget's theory is the most comprehensive available theory of cognitive development, and although some aspects of his theory have been disputed or even invalidated, the theory is still exceedingly influential, and rightfully so. Piaget's influence does not necessarily lie in what questions he answered about cognitive development but rather in what questions he raised. In discussing Piaget's theory, we discuss not only Piaget's own empirical work, but also more recent empirical work that arises out of questions Piaget asked but that may not have been done, strictly speaking, by "Piagetians."

Piaget was concerned with the analysis of different forms of knowledge. After receiving his PhD in zoology, he began to construct a biological account of the origins of knowledge, based on his understanding of biology and philosophy. Piaget began his work in cognitive development as a graduate student working in Alfred Binet's psychometric laboratory. There, he became interested in children's answers to intelligence-test items. He asserted that researchers could learn as much about children's intellectual development by examining their incorrect answers to test items as by examining their correct answers. By observing children's errors in reasoning, Piaget determined that coherent logical systems underlie children's thinking. These systems differ from the systems adults use, and in order to understand development, these systems and their distinctive characteristics must be identified. With this interest, he proceeded to write about his observations of children, especially his own.

Specific and General Heredity

Piaget's theory embraces two biological antecedents of cognitive development, specific heredity and general heredity. Specific heredity has several forms. The first, hereditary transmission of physical structures, dictates that all species have inherited biological structures that can inhibit certain accomplishments while promoting others (Ginsburg & Opper, 1988). One such structure is the eye. Gibson (1966) observed that predatory animals (e.g., wolves) inherited frontal eyes, which allow them to see what prey lies ahead. Conversely, primarily preyed-on animals (e.g., rabbits) usually inherit lateral eyes that provide the animal with peripheral vision to see predators.

Another aspect of specific heredity is the automatic behavioral reaction, or reflex. All members of a species, with the exception of those with defects, inherit the same physical mechanism that creates the reflex. The presence of a stimulus activates this mechanism that, in turn, causes the reflex. For example, the sucking reflex in human infants is necessary for the infants' survival. An infant does not need to be taught how to suck, and the response will enable the infant to eat. If an object (the stimulus) touches the infant's lips, the infant will automatically respond with sucking (the reflex). These reflexes are significant in the first few days of an infant's life. After that initial period, the infant's interactions with the environment modify the reflexes (Ginsburg & Opper, 1988).

A third form of specific heredity is physical maturation, where members of a species follow a genetically determined course for the growth of physical structures. This physical maturation is frequently correlated with psychological activities. As these physical structures mature, various activities are able to emerge. For example, as children age, their brains grow, their muscles become stronger, and their ability to speak emerges. Also, as their leg muscles strengthen, they gain the ability to walk, which allows them to explore the world. According to Piaget, physical maturation, coupled with experience and other factors, is necessary for development (Ginsburg & Opper, 1988).

The second biological factor in Piaget's theory is general heredity. General heredity comprises two basic inherited tendencies, or invariant functions: organization and adaptation. Organization is defined as individuals' inclinations to organize their physical and psychological processes into efficient systems. For example, young infants can either look at or grasp objects but cannot synchronize both actions. Following a period of development, these infants are able to organize these two activities into one process that allows them to grasp objects while looking at them (Ginsburg & Opper, 1988).

Adaptation is simply an individual's ability to fit into or adapt to the environment. Although adaptation is an inherited process, it usually differs across people and even within people at different stages of development. Adaptation occurs via a balancing of two complementary activities: assimilation and accommodation. Piaget (1952) borrowed these terms from physiology. When individuals eat, they assimilate the food to make it "like themselves." During this process, people also must accommodate to the food they eat by adjusting their digestion for the properties for each item of food.

In terms of cognitive processes, accommodation is the process by which people change in response to the demands of the environment. Assimilation is the process by which people integrate properties of the environment into their current internal psychological structures. Consider an example: Suppose a 4-month-old infant is presented with a rattle. This infant has never played with a rattle or a similar toy; therefore, the infant must adapt to the rattle. Because the infant has grasped objects in the past, grasping has become an internal behavioral structure for the infant. On seeing the rattle, the infant begins to assimilate the object by integrating it into this behavioral structure. The object becomes transformed into a familiar object—something that can be grasped. Concurrently, the child accommodates the rattle. In order for the infant to grasp the rattle successfully, the child must accommodate in several ways. First, the child's visual activities must be accommodated to locate the rattle. Next, the child's arm and hand movements must be adjusted to reach and grasp the toy. Then, to pick up the rattle, the infant's muscular exertion must be accommodated in response to the rattle's weight. Through this series of accommodations, the infant's behavioral structures are modified to meet the challenge of a novel object. Hence, in order for an infant to successfully deal with novelty, the indissociable processes of assimilation and accommodation must be implemented simultaneously (Ginsburg & Opper, 1988).

Schemes and Stages

As individuals organize their behavior and adapt to the environment, certain psychological structures result. These structures, called *schemes*, change as a child matures. Some schemes are innate, but most are not and are based largely on experience. For example, Piaget refers to the sucking reflex as the "sucking scheme." However, thumb sucking is not innate because, although sucking is a reflex, the act of moving the thumb to the mouth is learned.

When children do not change very much, they assimilate more than they accommodate. Piaget referred to this steady period as a state of cognitive equilibrium. During periods of rapid cognitive change, however, children are in a state of disequilibrium, where they accommodate more than they assimilate. They frequently have to modify their current schemes due to an influx of new information. Piaget referred to this back-and-forth movement from equilibrium to disequilibrium as *equilibration*. Equilibration ultimately produces efficient schemes (Piaget, 1985). Schemes that are similar and occur in the same developmental time period cluster together to form stages (Tanner & Inhelder, 1956).

According to Piaget's theory, children progress through a sequence of four major developmental stages: (a) the sensorimotor stage of infancy; (b) the preoperational stage of early childhood; (c) the concrete-operational stage of middle childhood; and (d) the formal-operational stage of adolescence. In advancing through these stages, the child progresses from a physical action to a symbolic action to a mental action as a predominant form of mental representation (Flavell, Miller, & Miller, 1993). This stage sequence is based on two important characteristics—invariance and universality—meaning that the stages always occur in the same order for all children. Also, skills gained in earlier stages continue into subsequent stages. Despite the genetically determined developmental order of these stages, genetic and environmental factors can affect the pace by which a child moves through the stages (Piaget, 1928). Therefore, note that ages presented in the brief discussion of the stages are rough estimates.

Sensorimotor development (birth to 2 years). The first stage, the sensorimotor stage, is divided into six substages because so much change occurs in children's first 2 years of life. Piaget believed that children are born with little knowledge about the world and a limited capacity to explore it. Because they need an effective way to modify their early schemes, Piaget asserted that infants use a circular reaction. Such reactions originate when infants accidentally generate a new experience because of their own motor activity. Through a process of trial and error, the infant tries to repeat the occurrence. This circular reaction has strengthened into a scheme for the child. Two other abilities that Piaget cited as occurring in the sensorimotor period are play and imitation. They have an important role in consolidating old schemes and developing new ones. Piaget viewed play as being a form of assimilation. Through play, children rehearse current schemes simply for pleasure. Piaget also associated imitation and accommodation. By imitating others, children copy and learn behaviors that are not in their inventory of schemes.

As discussed previously, the infant is born with various reflexes. Piaget believed that they are the infant's initial sensorimotor schemes, and therefore, the building blocks for later and more complex schemes. Piaget noted that many reflexes can be activated not only externally but also internally by the infant. In Substage 1: Reflexive Schemes (birth to 1 month), for example, a newborn will suck when presented with a nipple, but the newborn may also appear to suck when no stimuli are present.

Substage 2: Primary Circular Reactions (1 to 4 months) is characterized by the infant's ability to gain simple motor control through primary circular reactions. These are responses in which infants repeat actions that involve their bodies, including elementary motor skills that center around the infant's body such as thumb sucking and simple hand grasping. Also in this stage, infants experience some anticipation. Piaget (1952) described how his son would display sucking behavior, in anticipation of being fed, as soon as he was placed in his mother's arms. In addition, Piaget also determined that play and imitation make their first appearances in this substage. Infants appear to enjoy practicing their simple motor actions. According to Piaget, an infant at this stage can only mimic another person's imitation of the actions of the infant.

Substage 3: Secondary Circular Reactions (4 to 8 months) are responses on the part of the infant that produce responses from objects or people. Children in the stage of secondary circular reactions begin to display diverse motor skills. They learn to manipulate objects, sit up, and crawl. These skills direct their attention away from themselves and toward the environment. When children at this age discover an exciting behavior, such as banging a toy against a table, they will repeat this action. Children's ability to imitate grows at this stage. Here, they can assimilate more models and imitate more. However, children can imitate only those actions that they can already perform.

According to Piaget, a difference between substage 2 children and substage 3 children is that substage 3 children have a better formation of object concept, or object permanence. Piaget found that infants in substage 2 would not search for objects that seem to disappear, whether the object fell or was hidden. In contrast, 4- to 8-month-old children are able retrieve objects that are partially hidden. If a child is presented with a toy and watches while it is covered completely by a cloth, the child will not attempt to search for it. However, if part of the toy is left visible to the infant, the infant will lift the cloth to find the toy. Also, children at this age can anticipate where to look for an object. For example, if an infant drops a toy, the infant will anticipate where it will land, even if the descent of the toy was too fast to see. After a while, the infant will be able anticipate where an object dropped by someone else will land. This ability tends to appear after infants gain experience manipulating objects.

In Substage 4: Coordination of Secondary Circular Reactions (8 to 12 months), infants begin to coordinate their schemes to build more complex action sequences. As a consequence, infants become more skilled at two cognitive abilities—object permanence and goal-directed behavior. Piaget believed that in the first two substages, infants have no object permanence, and in the third substage, infants have the beginnings of it. Now, in the fourth substage, infants are more skilled at understanding that objects truly continue to exist when they are not in view. Therefore, when an object is completely covered by a cloth, the infant will lift the cloth off and grasp the object.

However, one experiment demonstrates that object permanence is not yet fully developed at this substage. If an object is hidden under cloth A, an infant will successfully uncover the object. But, if the object is moved to be located under cloth B, the infant will continue to look under cloth A. Piaget concluded that 8- to 12-month-olds make this AB (or A not B) search error because they cannot sustain a clear image of the object after the object is removed from their sight. He added that infants might have developed a sensorimotor "minihabit" during the procedure whereby they enjoy searching under cover A repeatedly; therefore, they do not look under cover B.

An infant in earlier substages discovers behaviors accidentally and only then will pursue them. However, a child in this substage will engage in goal-directed behaviors. At this point, infants have had a great deal of experience with various schemes, so they are able to coordinate several schemes to solve a variety of problems. Take the original object-permanence task, for example. In order to retrieve the hidden object, an infant must coordinate the scheme of removing the cover and grasping the object. Piaget considered this coordination to be the first real intelligent behavior and the basis for future problem solving.

By Substage 5: Tertiary Circular Reactions (12 to 18 months), children are no longer concerned only with themselves; they now have true interest in their surroundings. As a result, they have circular reactions—tertiary ones—that are novel, creative, and experimental and that allow them to explore the world. The children no longer stumble on behaviors only accidentally or repeat these behaviors incessantly. They now deliberately vary their repetitions to produce different outcomes. For example, infants will devote time to experimenting with a block and a hole, varying the orientation of the block until it fits the hole.

This experimentation with different types of objects provides a child at this substage with a better understanding of object permanence. The child will no longer make the AB search error because the child will search in several places until he or she finds the hidden object. Furthermore, children's ability to experiment and systematically to control their movements enables them to imitate a variety of unfamiliar behaviors in the presence of the model.

Piaget believed that infants, before reaching Substage 6: Mental representation (18 to 24 months), were quite limited in their ability to have mental representations of absent objects and previous events. This substage provides children with the ability to create mental representations, which includes the ability to use mental terms, symbols, and images to refer back to previously experienced events and objects. Children can now solve problems using mental representations instead of using circular reactions.

Suppose a child gets a toy stuck in the slats of a crib. A child younger than 18 months would move and pull the toy in a random manner until the toy comes loose. A child in substage 6 would study the situation and find a systematic way of loosening the toy, as if the child were mentally representing various solutions to the problem.

With the ability to represent objects and events mentally comes *deferred imitation*, which is the ability to repeat the behavior of a model who is no longer present. First of all, children at this age are able to imitate new behaviors without the numerous trials of a substage 5 child. Later, when the model is absent, the child can reenact the previously learned behavior. A well-known example of this deferred imitation is Piaget's (1952) description of his daughter, Jacqueline:

> Jacqueline had a visit from a little boy . . . whom she used to see from time to time, and who, in the course of the afternoon, got into a terrible temper. He screamed as he tried to get out of a playpen and pushed it backward, stamping his feet. Jacqueline stood watching him in amazement, never having witnessed such a scene before. The next day, she herself screamed in her playpen and tried to move it, stamping her foot lightly several times in succession. (p. 63)

Jacqueline's internalization of the boy's behavior was quite apparent because Jacqueline reproduced the event quite accurately a day after she witnessed it. It is assumed here that mental representation is required to remember and reproduce an event successfully. Mental representation also ushers in the beginnings of pretend play. Shortly before their second birthday, children start to pretend to act out familiar activities such as eating and sleeping.

Preoperational stage (2 to 7 years). The most noticeable change that children undergo from the sensorimotor stage to the preoperational stage is their tremendous increase in representational activity. Piaget recognized that language is an individual's most flexible means of representation. By thinking in words, individuals can deal with the past, present, and future at the same time and create powerful images of reality (Miller, 1993). However, Piaget did not consider language as creating higher forms of cognition. Instead, Piaget believed that experience with sensorimotor activity leads to mental images, which children, in turn, label with words. Piaget never clearly explained how this activity is transformed into images and then into words (Mandler, 1992).

The ability to understand that objects can be represented in pictures is an aspect of *symbolic-representational ability*, which blossoms in the preoperational stage. Parents would generally agree that toddlers understand that pictures stand for real objects. Their 2-year-old can point to a picture of a dog in a magazine and say, "Doggie." In fact, even young infants can recognize the similarities between pictures and their represented objects (e.g., DeLoache, Strauss, & Maynard, 1979), and their differences (e.g., Slater, Rose, & Morrison, 1984).

Young children do, however, run into some confusion with more difficult problems. For instance, suppose a child is watching a television show containing a helium balloon and then is asked, "If I take the top off the TV and then I shake it, would a real balloon come floating out into the room?" The majority of 3-year-olds would say "yes." When taught about the differences between photos of objects, videos of objects, and real objects, many more of them would answer correctly (Flavell, Flavell, Green, & Korfmacher, 1990). Flavell et al. proposed that 3-year-olds understand that objects and events on television are not real, but the children nevertheless have encoded them as real because the real-world referents of these objects and events are very salient. As a result, the children answer incorrectly (Flavell, Miller, & Miller, 1993). Children in this stage frequently fail difficult pictorial-representational tasks such as this one. What kinds of representations are possible at what ages and which behaviors demonstrate the representations is under debate (Perner, 1991).

Children's drawings reflect their symbolic expression. Toddlers' drawings, which are usually just simple scrawls, are considered to be "experiments in representation" (Winner, 1986, pp. 25–26). But between the ages of 3 and 4 years old, children begin to use lines to draw the boundaries of objects, which enables them to draw their first picture of a person. In addition, young children do not require that their pictures appear to be realistic.

Pretend play is another example of symbolic representation in the preoperational stage, which emerges around the age of 2 years. Its development has been written about extensively by researchers, including Bretherton (1984), Fein (1979a, 1979b), Garvey (1990), Goncu (1989), Leslie (1988), and Vygotsky (1978). Piaget (1951) viewed pretend play as an opportunity for a child to exercise symbolic schemes. This view is considered too narrow because research shows that pretend play also contributes to a child's social and cognitive skills (Singer & Singer, 1990). Children who spend a great deal of time in sociodramatic play—pretend play with others—tend to be more socially competent (Burns & Brainerd, 1979; J. A. Connolly & Doyle, 1984) and more imaginative and creative (Dansky, 1980; Pepler & Ross, 1981).

Pretend play comes from separating behaviors and objects from their actual use and using these behaviors and objects for play. For instance, a child eats dinner at dinnertime, in the kitchen, and usually when hungry. However, when pretending to eat dinner, a child can do so at another time, in another place, and in another physiological or psychological state. Lillard (1991) considered pretend play to be the deliberate "layering of a supposed situation over an actual one, in the spirit of fun rather than for survival" (p. 2). In order to pretend that a block is a car, the child must possess a mental representation of a car. The child intentionally replaces reality (that the object is a block) with the representation of a car. Children can treat props just as they treat the props' real referents, but they can also report that they are not the real referents—"That's *real* money, but that's not; those are *playing* money" (Woolley & Wellman, 1990).

However, preschoolers may not understand that pretending requires this mental representation. To test this notion, Lillard (1991) presented a troll doll to children and told them:

> This is Moe. He's from the land of the trolls. Moe's hopping around, kind of like a rabbit hops. Moe doesn't know that rabbits hop like that; he doesn't know anything about rabbits. But he is hopping like a rabbit. Does he know that rabbits hop like that? Is he hopping like a rabbit? Would you say he is pretending to be a rabbit, or he's not pretending to be a rabbit?

The majority of the 4-year-olds and many of the 5-year-olds reported that Moe *was* pretending to be a rabbit. They discounted the fact that Moe had never seen a rabbit before and could therefore not have formed a representation of a rabbit. If Moe acts like the referent, then the children believe that he is pretending to be the referent. Mental representation is not necessarily involved in their understanding of pretense. Further research by Lillard and Flavell (1992) showed that children perform better on such tasks when the pretense involves action (e.g., hopping) rather than just a mental state (e.g., thinking like a rabbit thinks).

Piaget (1950) considered children in this stage to be *egocentric* with respect to their symbolic viewpoints. They believe that everyone else's thoughts, feelings, desires, and perceptions are the same as theirs. An interesting demonstration of this egocentrism is shown in Piaget's three-mountains problem. Children stand on one side of a display that has three mountains of different heights on it and a doll is placed at various locations on the display. The child has to choose, for each location, the picture that shows what the doll sees. Most children younger than 6 or 7 years choose the picture that shows the display from their own point of view (Piaget & Inhelder, 1956).

Piaget believed that egocentrism is responsible for several preoperational tendencies, including *animistic thinking*. Animistic thinking is attributing human qualities, such as thinking, feeling, and perceiving, to inanimate objects (Piaget, 1930). Piaget claimed that egocentrism is also responsible for children's erroneous and inflexible thinking. Because they are unable to consider other people's points of view, they do not accommodate in response to feedback from their environment.

More recent research finds children to be less egocentric than Piaget expected. For instance, when the original three-mountains display is changed to include familiar items, and when children are given the chance to report what the doll sees by methods other than selecting a picture, even 4-year-olds can pass the task (Borke, 1975; Newcombe & Huttenlocher, 1992). Also, research has found children to have less animistic beliefs than Piaget thought. Piaget questioned children about objects with which they have minimal experience, such as the sun and the moon. When questioned about familiar objects, 3-year-olds are able to report that the objects are not alive. They report, however, that vehicles, such as trains, are alive, but it is probably because the objects move as many living things do (Dolgin & Behrend, 1984; Massey & Gelman, 1988; Richards & Siegler, 1986).

Concrete-operational stage (7 to 11 years). When children reach the concrete-operational stage, their thought resembles adult thought more so than the thought of a sensorimotor or a preoperational child because their reasoning becomes more flexible, logical, and organized, and thus more powerful (Piaget & Inhelder, 1969). This period is marked by the acquisition of operations. Prior development has placed the groundwork for this achievement. Children in the sensorimotor stage learned to interact physically with the world; preoperational children learned to represent states mentally. Concrete-operational children learn as well to manipulate their mental representations internally. Operations are characterized by their ability to be reversed and to be organized with other operations into greater systems. Children acquire logicoarithmetical operations, including concepts like class inclusion, conservation, and perspective taking; and spatial operations, including comprehension of distance, time, velocity, and space. However, concrete-operational children are limited; they can think only about concrete information. Their operations fail when applied to abstract ideas. Although their problem-solving ability mushrooms, they cannot do certain types of abstract reasoning. This ability is acquired in the formal-operations stage.

Piaget believed that his stages are universal, and that concrete-operational thinking is not dependent on experience (see Cole, chapter 3, this volume). However, more recent research suggests that specific cultural practices are related to children's proficiency on Piagetian tasks (Rogoff, 1990). For example, some studies have shown that conservation in non-Western societies is frequently acquired later than in Western societies, thereby suggesting that schooling promotes proficiency on such tasks. One study by Fahrmeier (1978) found that Hausa children in Nigeria do not succeed on basic conservation tasks until age 11. It has been proposed that this finding may be due to the fact that these children rarely attend school. In addition, many Western children learn quantity early (e.g., how to divide and share fairly), but children in other cultures may not share these experiences. Therefore, their conservation would appear later (Light & Perret-Clermont, 1989). However, other studies of concrete operations showed no differences between schooled and nonschooled children and sometimes even greater success for nonschooled children (Kiminyo, 1977; Nyiti, 1976; Strauss, Ankori, Orpaz, & Stavy, 1977). One explanation of this inconsistency is that success on Piagetian tasks is based on familiarity with the materials and the concepts and not on amount of schooling (Irwin, Schafer, & Feiden, 1974; Kelly, 1977; Price-Williams, Gordon, & Ramirez, 1969).

Formal-operational stage (11 years onward). This stage is characterized by the ability to "operate on operations" because adolescents and near-adolescents can now think abstractly (Inhelder & Piaget, 1958). Three main capabilities arise: reasoning with abstract possibilities, hypothetico-deductive reasoning, and propositional thought.

Concrete-operational children tend to look for the solution to conceptual problems by manipulating the data with their logical concrete-operational skills. They seek the one real answer. On the other hand, formal-operational adolescents and adults tend to work in the opposite direction: They start with possible solutions and progress to determine which is the real solution, called *reasoning with abstract possibilities*. Unlike formal-operational thinkers, concrete-operational thinkers cannot work in the realm of abstract possibility. They opt for the realm of tangible reality (Flavell, Miller, & Miller, 1993).

Formal-operational thinkers reason with problems in another way. They inspect the given data, form a hypothesis about what possibly could be the correct explanation, deduce whether it logically can occur in reality, and then test their theories to see whether their predictions hold, called *hypothetico-deductive reasoning*. If any of these steps fall short, the process is reiterated. These theories are conceptual entities constructed by abstract thinkers after careful analyses of the problem situations. These are not representations of the perceived situation (Flavell, Miller, & Miller, 1993).

For example, for her science project, Angela wanted to determine whether playing classical music would affect the growth rate of plants. She hypothesized that music would cause the plants to grow faster. She realized that light, food, and water play an additional role in the plants' growth, so she designed an experiment that provided comparable environments for the plants in both experimental conditions. Angela was able to conceive an hypothesis, realize other factors that could have a possible effect on the outcome of her experiment, and test out her hypothesis in an organized manner. Her thinking demonstrates formal-operational thinking.

There is a difference between the way concrete-operational thinkers and formal-operational thinkers handle propositions. Concrete-operational thinking, termed *intrapropositional thinking* by Piaget, involves considering propositions as single entities and testing each one individually against reality. Concrete-operational thinkers look only for a factual relation between a single proposition and reality. A formal-operational thinker goes one step further and reasons about the logical relations that exist between two or more propositions. Piaget dubbed this more abstract form of reasoning *interpropositional* (Flavell, Miller, & Miller, 1993).

One study of propositional thought by Osherson and Markman (1975) involved an experimenter showing children and adolescents a pile of poker chips of various colors. The experimenter told the participants that they would hear statements about the chips and that they should report whether the statements are true, false, or uncertain. In one condition, a chip is concealed in the experimenter's hand and the participants are told, "Either the chip in my hand is green or it is not green," or "The chip in my hand is green and it is not green." In another condition, the experimenter held up either a green or a red chip for the participants to see and made the same statements. The children focused on the concrete properties of the poker chips rather than on the logical properties of the experimenter's statements. When the chip was hidden, they would report they were uncertain to both statements. Yet, when the chip was visible, the children reported both statements to be true if the chip was green and false if it was red. Therefore, when the color of the visible chip matched the color mentioned in the statement, the children reported the statement to be true, but when the colors did not match, the children reported the statement to be false. In contrast, adolescents focused on the logic of the statements rather than on the appearance of the chips. Unlike the children, they understood that, in the context of the experiment, either–or statements were always true and "and" statements were always false (Moshman & Franks, 1986; Russell & Haworth, 1987).

Cross-cultural studies of Piagetian tasks in the 1960s and 1970s showed that people in many cultures do not seem to achieve formal operations without schooling (e.g., Ashton, 1975; Goodnow, 1962; Laurendeau-Bendavid, 1977). In response to this finding, Piaget (1972) repealed his claim that his stages are universal, because achieving formal operations is dependent on experience with the specific scientific thinking found in science classes and is thereby not domain- and culture-free.

Evaluation of Piaget's Theory

In summary, Piaget's theory of cognitive development involves stages. To Piaget, stages occur at roughly the same ages for different children, and each stage builds on the preceding stage. Stages occur in a fixed order and are irreversible: Once a child enters into a new stage, the child thinks in ways that characterize that stage, regardless of the task domain, the specific task, or even the context in which the task is presented. He or she never thinks in ways that characterize an earlier stage of cognitive development. Other theorists (e.g., Beilin, 1971; R. Gelman, 1969), including some neo-Piagetians (e.g., Case, 1992; Fischer, 1980), disagree with this view, suggesting that there may be greater flexibility in the cognitive-developmental progression across tasks and task domains than Piaget suggested.

Because Piaget's theory is extensive yet based in large part on Piaget's observations of his own children, a great deal of research in the field of developmental psychology has been dedicated to either upholding or discrediting his claims. Some criticisms center on specific claims of Piaget, whereas others criticize Piaget's theory as a whole. We discuss first various research studies disputing specific claims of Piaget, and then we discuss some problems with the fundamental aspects of Piaget's theory.

Research on Piaget's object permanence. The most heavily researched area of Piaget's theory is object permanence, particularly when it appears and how it can be tested. Piaget asserted that object permanence develops from manipulating objects, a skill he believed emerges in substage 4. Yet, all his tests of object permanence involve infants' reaching for objects. Using reaching tests may underestimate infants' conceptual abilities because the infants' failure to respond correctly may be due simply to infants' immature motor systems (Baillargeon, 1993; Diamond, 1990; Mandler, 1988). In Piaget's tests, the infant has a difficult task of removing the cover before grasping the object. Regardless, Piaget concluded from these tests that young infants are lacking the ability to represent objects mentally. More recently developed tests seem to show otherwise.

The habituation/dishabituation test is a useful and popular way to study object permanence without requiring the infant to reach for an object (see Bornstein & Arterberry, chap. 6, this volume). It requires the participants only to look at perceptual displays. Baillargeon and Spelke were among the first to use the test for this purpose (Baillargeon, Spelke, & Wasserman, 1985). In a collection of studies by Baillargeon (1987, 1991; Baillargeon & DeVos, 1991) that used this method, it was found that infants as young as 3½ months old showed indications of object permanence (for further details, see Baillargeon & DeVos, 1991). This finding, combined with those of Spelke (e.g., 1991; Spelke, Breinlinger, Macomber, & Jacobson, 1992), lends credence to the hypothesis that young infants fail Piaget's original tests because the tests require behaviors of which the infants are not yet capable (e.g., reaching). Research suggests that infants probably have some understanding that hidden objects continue to exist, and this understanding comes months earlier than Piaget had thought, and maybe even from birth.

The AB search error has been the most researched aspect of object permanence. Studies have replicated the substage 4 error (e.g., Wellman, Cross, & Bartsch, 1987), but resultant explanations do not necessarily fit with Piaget's explanation of the phenomenon. Piaget's explanation is that infants experience pleasure from searching under cover A repeatedly. If this were the case, then infants would be more likely to make the error if they were presented with more successful search trials under A before the object was hidden under B. Also, infants should make the error more if they were the ones who successfully uncovered A instead of just watching the experimenter uncover it. However, research conducted by Harris (1983) does not support these predicted outcomes.

Additional research has proposed variables not mentioned by Piaget, such as memory capacity. Diamond (1985) showed that a time delay of a few seconds from when the object is hidden under B and when the infant can search for it is sufficient to cause the error. This outcome could occur because infants' working memory is immature. Their memory for the object's appearance at A is much stronger than their memory for the object's disappearance at B. On the other hand, Baillargeon et al. (Baillargeon, DeVos, & Graber, 1989; Baillargeon & Graber, 1988) have found that infants are able to remember the location of an object after a substantial time delay (up to 70 seconds) in tasks in which the infant does not have to search for the object actively.

Diamond (1991a, 1991b) also proposed that the error might be due to infants' inability to inhibit a prepotent (dominating) response. Even if infants know that the object is at

B, and Diamond notes that they frequently do appear to know, they cannot inhibit the tendency to search A as they had done several times in the past. In conclusion, research has shown that infants have a concept of object permanence earlier than Piaget had believed, but it has not been determined when it is developed. Also, there are several sound theories about what causes the AB search error, but no one theory has been agreed on to explain the entire phenomenon. Most likely, some combination of the reasons presented in the theories contributes to the error.

Research on mental representation according to Piaget. According to Piaget, sensorimotor activity in the first five substages prepares children for representational ability in the sixth. This momentous achievement marks the end of the sensorimotor period and the beginning of a higher level of intellectual functioning. Piaget believed that before the sixth substage, infants had no representational ability. However, more recent studies indicate that the ability may emerge in infants earlier than Piaget thought. For example, many researchers maintain that object permanence demonstrates the ability for representation prior to substage 6, because these researchers believe that object permanence requires a representation of the object.

A second example is taken from work on deaf children's early acquisition of American Sign Language (ASL). It has been found that deaf infants, as early as 6 to 8 months of age, clearly begin to use symbolic signs (Folven & Bonvillian, 1991; Mandler, 1988; Meier & Newport, 1990).

A third example comes from studies of deferred imitation, one of Piaget's measures of representational activity. Meltzoff (1985, 1988a, 1988b) found that infants as young as 9 months of age, after a 24-hour delay, were able to reproduce actions they observed only once. In addition, 14-month-olds were able to reproduce actions after a delay of 1 week. Similarly, McDonough and Mandler (1994) found that 11-month-olds were able to reproduce at least one unusual event observed 1 full year earlier. Work on deferred imitation also suggests that recall memory probably emerges during the first year of an infant's life (Mandler, 1998).

A fourth example of early representation is an infant's ability to categorize objects and events. In one study, 3-month-olds kicked vigorously at a mobile made up of uniform blocks with the letter A on them. After a delay, infants would only kick vigorously if presented with the mobile with letter A blocks. If presented with a different mobile (blocks with the number 2 on them), they would not kick vigorously. Therefore, infants mentally had categorized the physical features of the mobile. They associated the A's with their kicking and later distinguished the 2s from the A's (Hayne, Rovee-Collier, & Perris, 1987). Additional studies have suggested that 9- to 12-month-olds can categorize objects into groups including stuffed animals, vehicles, food, birds, and gender (Francis & McCroy, 1983; Oakes, Madole, & Cohen, 1991; Roberts, 1988; Ross, 1980; Sherman, 1985). Because there are theoretical and empirical objections to Piaget's theory of representation, others have provided alternative accounts (see Karmiloff-Smith, 1992; Leslie, 1994; Mandler, 1988, 1992).

Research on Piaget's views on problem solving. Piaget reported that rudimentary tool use appears in substage 5. However, several studies have shown that elementary tool use may emerge earlier than Piaget thought (e.g., Bates, Carlson-Luden, & Bretherton, 1980; Brown, 1989; K. Connolly & Dagleish, 1989; Užgiris & Hunt, 1975, 1987). In a study by Willatts (1989), 9-month-old infants were presented with an enticing toy that was out of their reach. The toy was on a cloth that was close enough for the infant to reach. However, a foam block prevented the infants from reaching the cloth.

To obtain the toy, the infants had to remove the block, reach for and pull the cloth, and then retrieve the toy. Young infants, even those as young as 9 months of age, were able to solve this problem on the first trial. Because they were able to figure out the solution so quickly and did not need to try out various solutions, 9-month-old infants demonstrated intelligent planning behavior that Piaget believed only appears at the end of the sensorimotor period. In a similar study by Kolstad and Aguiar (1995), 6½-month-old infants were able to pull the cloth and retrieve the toy after being provided with a hint. Infants of this age may not solve problems on their own, but when presented with a basic problem and the right conditions, they have the capability to solve it.

In summary, infants demonstrate skills earlier than Piaget had thought. However, these newly formed skills may not be strong enough when they first appear to affect infants' understanding of their environment. Achievements are posited as occurring in Piaget's stages when they are fully developed and functional, not necessarily when they first appear. Because achievements have been shown to emerge earlier than Piaget's stages indicate, exactly when these stages occur cannot be established.

Criticisms of the fundamentals of Piaget's theory. One criticism directly questions Piaget's assertion that the changes in children's cognition occur chiefly as an outcome of maturational processes. Although Piaget observed that developmental processes result from children's adaptations to their environment, he held that internal maturational processes, rather than environmental contexts or events, determine the sequence of cognitive-developmental progression. Evidence of environmental influences on children's performance on Piagetian tasks contradicts this premise. In particular, Piagetian theory is contradicted by evidence (e.g., Fischer & Bidell, 1991; R. Gelman, 1972; Gottfried, 1984) that particular experiences, training, or other environmental factors may alter performance on Piagetian tasks.

A second criticism arises because many developmental theorists question Piaget's fundamental assumption that cognitive development occurs in a fixed sequence of discontinuous stages across task domains, tasks, and contexts. Regarding the discontinuity of development, many theorists (e.g., Brainerd, 1978) believe that cognitive development occurs as a continuous process rather than in discontinuous stages of development. Additionally, accumulating evidence (e.g., Beilin, 1971; see also Bidell & Fischer, 1992; Case, 1992) contradicts the assumption that within a given stage of development, children demonstrate only stage-appropriate levels of performance. It now appears that many aspects of the child's physical and social environment, of the child's prior experiences with the task and the task materials, and even of the experimenter's presentation of the task itself may lead to apparent unevenness in cognitive development. Although Piaget allowed for some differences across task domains through a construct he called *horizontal décalage*, the mechanism underlying this construct was never clearly explained, and in the context of the theory, it seemed to be an after-the-fact explanation rather than a motivated part of the entire picture.

Third, theorists and researchers have questioned Piaget's interpretation regarding what causes difficulty for children in particular Piagetian tasks. Piaget's theory emphasizes the development of deductive and inductive reasoning, and Piaget held that limitations on children's ability to reason cause their difficulties in solving particular cognitive tasks. Different theorists have suggested that other kinds of limitations may at least partly influence children's performance on Piagetian tasks. Such limitations include children's motor coordination (Mandler, 1990), working-memory capacity (e.g., Bryant & Trabasso, 1971; Kail, 1984; Kail & Park, 1994), memory strategies (Siegler, 1991), or verbal understanding of questions (e.g., Sternberg, 1985). For example, some researchers have suggested that children might not have understood Piaget's questions, so his experiments may have failed to elicit the children's full complement of abilities. In general, Piaget appears to have underestimated the importance of language and its development in this theory.

Fourth, many theorists have questioned the accuracy of Piaget's estimates of the ages at which people demonstrate mastery of Piagetian tasks. Piaget underscored the importance of noting the sequence of developments, not the estimated ages at which these developments occurred. In general, the trend has been toward demonstrating that children can do things at ages earlier than Piaget had thought possible (see, e.g., Baillargeon, 1987; Brainerd, 1973; R. Gelman, 1969; R. Gelman & Baillargeon, 1983). Piaget's estimates of ages may have been skewed by his use of somewhat loose methods of research and of tasks that required responses that were complex or hard to understand.

The evidence cited against Piaget's theory often refers to children's inconsistent abilities to perform well on tasks believed to be beyond their stage of development. However, Thelen and Smith (1994) presented a new approach to development that assuages many of the apparent problems for Piaget's theory. In particular, Thelen and Smith's *dynamic-systems approach*, in which discontinuities occur as part of the natural interaction of nonlinear dynamic systems (systems with highly complex physical properties—in this case, children and their environment), predicts the very kinds of conflicting performance seen in children on the verge of stage transition. Thelen and Smith pointed out that instability is necessary in order for new abilities to develop—a system must contain variability in its behavior in order for new behaviors to be selected. According to Thelen and Smith, children move from equilibrium in ability level to points of instability in performance, in which they are able to perform beyond their current stage inconsistently in some contexts. Furthermore, this disequilibrium is part of the natural interaction of the nonlinear dynamic systems involved in children's interactions with their environment. Thus, the dynamic systems approach to development encompasses conflicting evidence into a new framework—children do progress through stages, but not strictly via maturation. The discontinuous stages proposed by Piaget and the apparent conflicts in children's performance at stage transition result from natural interactions between children and their environment.

These ideas notwithstanding, even adolescents and adults do not show formal-operational thinking under many circumstances (Dasen & Heron, 1981; Neimark, 1975). They often seem to think associatively rather than logically (Sloman, 1996). In 1972, Piaget modified his own theory to acknowledge that the stage of formal operations may be more a product of an individual's domain-specific expertise, based on experience, than of the maturational processes of cognitive development.

Piaget's theory might also be criticized for emphasizing heavily logical and scientific thinking in development. Some modern theories of intelligence emphasize other domains, for example, domains of musical, bodily-kinesthetic, or interpersonal thinking (e.g., Gardner, 1983). Piaget's theory gave short shrift to such domains.

Finally, the variations in the ages at which particular cognitive tasks are mastered show that most of us have a wide range of performance, so that what we may be capable of doing optimally often may differ from what we do actually much of the time. The context in which we typically demonstrate cognitive performance may not be a true indication of what we are optimally able to achieve—and vice versa. One way of viewing these apparent contradictions is to describe Piaget's theory as primarily a competence theory—a theory of what people of various ages are maximally capable of doing. Other theorists prefer to view cognitive development in terms of a performance theory—a theory of what people of various ages naturally do in their day-to-day lives (see Davidson & Sternberg, 1985).

Piaget's descriptions of infant development and the research methods he used are commendable and historically important, but the theory he posed originally has not endured.

NEO-PIAGETIAN THEORIES

The neo-Piagetian theories of cognitive development are based on Piaget's theory but address some of the problems with his theory by modifying it. Although there are vastly different neo-Piagetian theories, most make use of Piaget's idea of developmental stages, concentrate on the scientific and logical aspects of cognitive development (frequently observing children in much the same way as Piaget had), and preserve the idea that development occurs through equilibration. Although there have been many important contributions made by various neo-Piagetians (e.g., Demetriou & Efklides, 1987, 1994; Halford, 1993), here we focus on three neo-Piagetian theories: fifth-stage, Case's, and Fischer's theories.

Fifth-Stage Theorists

Fifth-stage theorists maintain Piaget's four stages of development and add a fifth stage. For example, Arlin (1975) suggested a fifth stage called *problem finding*. During this stage, people become adept at determining what problems they face and which problems are most important for them to solve. Other theorists, including Kramer (1983), Labouvie-Vief (1980, 1985), Pascual-Leone (1988), and Riegel (1973) proposed a final stage called *postformal* or *dialectical thinking*. In this stage, people begin to recognize the continuous unfolding and evolution of thought, and they become able to weigh and suggest various solutions to problems.

Case's Theory

Case (1985, 1992), like Piaget, proposed that children move through four developmental stages. The types of mental representations children can form and the types of responses they give in each stage characterize these stages. In the first stage, sensorimotor operations, children's representations consist of sensory input, and their responses to this input are physical movements. In the second stage, representational operations, children's representations involve concrete mental images, and their responses can produce additional mental representations. In the next stage, logical operations, children have the abilities to represent abstractly and respond to stimuli with simple transformations. The final stage, formal operations, differs from the previous stage in that children continue to represent stimuli abstractly, but they can now execute complex transformations of the information.

For example, during the sensorimotor-operations stage, a child may see a toy (sensory input) and reach for it (motor response). In the representational-operations stage, a child can generate a mental image of the toy (internal representation), and then use the mental image to describe the toy to a parent (representational action). A child in the logical-operations stage may realize that two of his friends do not like each other (abstract representation) and tell them that they could have more fun if all three of them were friends (simple transformation). In the formal-operations stage, the child may realize that it is hard to form friendships in such a way (abstract representation) and then lead his friends into a situation where they would need to overcome some danger, which would then create friendships (complex transformation; Siegler, 1991).

Another aspect of Case's theory of cognitive development is his view of cognitive change. Case regards cognitive change as the ability to deal with more and more elements of a problem. In one of his demonstrations of the existence of this ability, he placed an infant at one end of a balance beam. Case showed the child that if the balance beam were pushed down, it would ring a bell. A young infant would only be able to follow visually the beam's movements. Infants between 4 and 8 months would be able to push down the beam and ring the bell, thereby coordinating two actions—visual tracking and hand movements—instead of one isolated activity (visual tracking) as before. A child between 8 and 12 months would be able to incorporate another property in a modified version of this problem, when the bell was moved out of the child's sight and placed on a different part of the beam. Although in this problem the same pushing movements would ring the bell, the child would need to consider additional information in order to ring the bell. Finally, 12- to 18-month-old children were able to succeed when the problem required the children to push the beam up instead of down. Younger children were not able to reverse the learned action, as they consistently pushed the beam down and became upset when the bell would not ring as it had in the past.

Case's explanation for older children's success on the final problem is that the problem contains two units, the pushing of the beam and the ringing of the bell, which are separate enough for older children to be able to see their reversible relation. The children are able to see that when one end of the beam goes down, the other end goes up, and vice versa. Within Case's theory of development, the execution of this behavior shows that a child has the ability to form subgoals (pushing beam) in order to reach a final goal (ringing bell). The behaviors that lead up to a child's success on a given problem illustrate cognitive change. In order to reach a goal, a child must either draw on learned strategies or formulate new ones. Children's collections of strategies expand as they mature. They gain mental capacity and the ability to deal with more information.

Fischer's Skill Theory

Fischer's (1980) theory of cognitive development, named *skill theory*, is similar to that of Case in that both theories are based on Piagetian-like stages. However, Fischer differs in some fundamental ways from Piaget, Case, and other recent theorists. For example, Fischer places more emphasis on specific experiences than do Piaget and Case. Also, most other stage theories explain large-scale changes in cognitive development as being caused by increases in the number of items in working memory. According to skill theory, however, changes occur because of a crucial change in the organization of behavior. In addition, other theorists presume that when individuals reach a particular level, their skills are also at that level. On the other hand, Fischer believes that behavior at a particular level can vary vastly and skills do not necessarily have to be at that level.

Fischer has proposed two types of processes within his skill theory to explain development and learning that lead to large-scale changes in development—*optimal level* and *skill acquisition*. Optimal level is defined as the upper limit of one's general information-processing capacity. Through maturation, a person's optimal level increases; therefore, a person becomes able to handle more and more complex skills. A person can perform at an upper limit only if the person's performance is shaped and supported by the environment. Skill acquisition is a set of transformation rules that determines how a person can have a particular skill in one context and then adapt it to form a new skill in another context.

Skill theory describes 10 developmental levels within three tiers. Each tier consists of four consecutive levels, and each level involves a new kind of skill organization. The first tier, termed the sensorimotor actions tier, comprises (a) single sensorimotor set, (b) sensorimotor mapping, (c) sensorimotor system, and (d) system of sensorimotor systems, or a single representational set. The second tier, termed the representational tier, comprises the fourth level plus (e) representational mapping, (f) representational system, and (g) system of representational systems, or a single abstract set. The third tier, termed the abstract tier, comprises the seventh level plus (h) abstract mapping, (i) abstract system, and (j) system of abstract systems, or a single principle (Fischer & Pipp, 1984).

Fischer and Pipp (1984) illustrated the representational tier with pretend play because pretend play in terms of skill theory has been investigated at great length in various experiments (e.g., Corrigan, 1983; Fischer, Hand, Watson, Van Parys, & Tucker, 1984; Hand, 1981, 1982; Watson, 1981). In a 24-month-old middle-class child, the first level of the representational tier, single representations, appears. The simplest representation the child can do is to make a doll carry out a simple act, such as eating baby food. Within a level, skill acquisition can evolve a simple skill into a more complex skill. For example, a more complex skill is creating a behavior role for the doll. For instance, the child could make the doll become a mother and act as the child thinks a mother should act.

In the next level, representational mappings, the child can coordinate two or more representations. For example, the child can take two dolls and have them interact, thereby creating a behavioral role, as before, and adding a social role. In this case, the child could take the mother doll and create a baby doll and have them interact. The baby tells the mother that he is hungry, the mother feeds him, and the baby says he is full (Fischer & Pipp, 1984). The next level is a system of representations that comprises at least two mappings. At this level, a child can make two dolls act out two social roles at the same time and have them interact with each other. For instance, the dolls can be in both parental and professional roles such as a father who is also a teacher and a mother who is also a doctor (Fischer & Pipp, 1984).

Within the final tier, which is a system of systems, or a single abstraction, the child can coordinate two or more systems. For example, children would be able to abstract that a family is a system of parental and spouse roles by coordinating their system for understanding their families' roles with their system for understanding their best friends' families' roles (Fischer & Pipp, 1984).

These neo-Piagetian theories are similar to Piaget's in that they define development as moving through a series of stages and achievements. They each attempt to address many of the shortcomings in Piaget's theory but, like other theories, still do not account for all aspects of development.

VYGOTSKY'S SOCIOCULTURAL THEORY

Although Russian developmentalist Lev Vygotsky (1896–1934) died young—at 38 years of age—he has been held in the same level of regard as Jean Piaget in the field of developmental psychology. Whereas Piaget's theory of cognitive development was dominant in the 1960s and 1970s, Vygotsky's theory was rediscovered in the late 1970s and continues to influence current theories and research. Piaget believed cognitive development proceeds largely "from the inside out" through maturation. According to Piaget's theory, environments can foster or impede development, but Piaget emphasized the biological and hence the maturational aspect of development. Vygotsky's (1962, 1978) theory takes an entirely different approach in emphasizing the role of the environment and social interaction in children's intellectual development. Although Vygotsky made many important contributions to furthering our understanding of cognitive development, we only discuss two of his ideas: internalization and the zone of proximal development.

Internalization

Vygotsky suggested that cognitive development proceeds largely from the outside in, through *internalization*—the absorption of knowledge from context. Thus, social, rather than biological, influences are key in Vygotsky's theory of cognitive development. According to Vygotsky, then, much of children's learning occurs through the child's interactions within the environment, which determine largely what the child internalizes.

Consider, for example, a little girl on a lurching train. As the train is bumping along, she rises to walk in the aisle. Suppose that her mother simply says authoritatively, "Sit down," without explanation. An opportunity for learning has been lost. The child may neglect to infer the reasoning underlying her mother's request. However, suppose instead that the mother says, "Sit down because the train might jerk or sway suddenly, and you might fall." The child now has an opportunity not only to modify her behavior, but also to learn how to use this modification in other appropriate circumstances. Thus, the parent and others in the child's environment may extend the child's knowledge and may facilitate the child's learning through their interactions with the child.

Zone of Proximal Development (ZPD)

This interactive form of learning relates to Vygotsky's second major contribution to educational and developmental psychology—the construct of the zone of proximal development (ZPD; sometimes termed the zone of potential development). The ZPD is the range of potential between a child's observable level of realized ability (performance) and the child's underlying latent capacity (competence), which is not directly obvious. In other words, ZPD refers to a range of tasks that children are not able to manage on their own but can manage with the aid of adults and more skilled children. Cognitive change involves moving through the zone of proximal development, where children build on what they already understand.

When we observe children, what we typically observe is the ability that they have developed through the interaction of heredity and environment. To a large extent, however, we are truly interested in what children are capable of doing—what their potential would be if they were freed from the confines of an environment that is never truly optimal. Before Vygotsky proposed his theory, people were unsure how to measure this latent capacity.

Like Piaget, Vygotsky was interested not only in children's correct responses, but also in their incorrect responses to questions. Vygotsky argued that we need to reconsider not only how we think about children's cognitive abilities, but also how we measure them. Children are usually tested in a static assessment environment, in which the examiner asks questions and expects the child to answer them. Regardless of whether the child responds correctly or incorrectly, the examiner proceeds to the next question or task on the list of items on the test. Thus, Vygotsky recommended that we move from a static assessment environment to a dynamic assessment environment. Here, the interaction between child and examiner does not end when the child responds, especially if the child responds incorrectly. In this case, the examiner provides the child with a graded sequence of guided hints in order to facilitate the child's problem solving. In other words, the examiner serves as both teacher and tester.

Researchers use the child's ability to benefit from hints as the basis for measuring the child's ZPD because this ability indicates the extent to which the child can expand beyond her or his observable abilities at the time of testing. Two children may answer a given problem incorrectly. However, a child who can profit from instruction can potentially go far, whereas a child who cannot is unlikely to acquire the skills needed to solve not only the problem being tested, but related ones as well. Several tests have been created to measure ZPD (e.g., Brown & French, 1979; Campione, 1989; Campione & Brown, 1990), the most well known of which is Feuerstein's (1979) *Learning Potential Assessment Device*. It should be added that although Feuerstein's test addresses the construct, Feuerstein views himself as having derived the construct independently.

ZPD is one of the more exciting concepts in cognitive-developmental psychology, as it may enable us to probe beyond a child's observed performance. Moreover, the combination of testing and teaching appeals to many psychologists and educators. Educators, psychologists, and other researchers have been captivated by Vygotsky's notion that we can extend and facilitate children's development of their cognitive abilities.

Vygotsky's theory has generated interest in and further research on social influences on cognitive change (e.g., Bronfenbrenner, 1979, 1989; Bruner, 1990; Cohen & Siegel, 1991; Resnick, Levine, & Teasley, 1991; Rogoff, 1990; Valsiner & van der Veer, 1993; Wertsch, 1991). Recent work has focused on what support and stimulation adults provide children (Rogoff, 1998). One example is scaffolding, a concept proposed by Wood, Bruner, and Ross (1976). Effective scaffolding occurs when adults adjust their facilitation in relation to children's level of performance. For instance, when a child is a novice, the adult provides direct, hands-on instruction. Later, as the child becomes more competent, the adult's assistance decreases in response to the child's achievements. The adult's assistance relates contingently on the child's failures and accomplishments.

Both Piaget and Vygotsky—arguably the two most influential cognitive-developmental psychologists to date—urged us not to be content just to note whether children's responses to questions and tasks are accurate. The power of these two developmental psychologists lay in their interest in probing beneath the surface, trying to understand why children behave and respond as they do. As is true of almost any significant contribution to science, the ideas of Vygotsky and of Piaget are measured more by how much they prompt us to extend our knowledge than by how nearly perfectly they have represented a complete, final understanding of the developing human mind. Perhaps the most we can ask of a theory is that it be worthy of further exploration. Next, we consider cognitive development as studied in the realm of information-processing skills.

COGNITIVE APPROACHES

Information-Processing Approach

Unlike the theories of Piaget and the neo-Piagetians, information-processing theories are not centered around developmental stages but instead focus on the operations of the mind. Information-processing theorists view the mind as a complex system, similar to that of a computer, that manipulates information that comes into it or that is currently stored in it. They seek to explain cognitive development in terms of how people of different ages process information (i.e., decode, encode, transfer, combine, store, and retrieve it), particularly when solving challenging mental problems. We should state at the outset that the available information-processing theories do not claim to provide as comprehensive and as well-integrated an explanation of cognitive development as did Piaget or Vygotsky. At the same time, information-processing theorists, taken as a whole, consider the entire range of cognitive processes that manipulate information in persons of all ages. Any mental activity that involves noticing, taking in, mentally manipulating, storing, combining, retrieving, or acting on information falls within the purview of information-processing approaches: How do our processes, strategies, or ways of representing and organizing information change over time, if at all? If there are changes, what might cause them?

The information-processing approaches focus on four basic attributes or assumptions. The first assumption is that thinking is information processing. Information-processing theorists focus on what information children represent, what processes they use to transform the information, and what memory limitations restrict the amount of information they can represent and process. In other words, the quality of children's thinking is determined by what information the children can represent in a particular situation, how they use the information to reach their goal, and how much information they can retain at one time (Siegler, 1991).

The second assumption of these theories is in their particular analysis of change mechanisms in terms of changes in information processing. Information-processing theorists strive to identify the change mechanisms that contribute the most to development and to define how these change mechanisms cooperate to produce cognitive growth. At the same time, information-processing theorists strive to understand the cognitive limitations on development. As a result, two goals of these theorists are to understand how children of a particular age have reached a certain point and why the children have not exceeded that point (Siegler, 1991).

The third assumption that most information-processing theorists make is that a process of constant self-modification causes change. Thus, how a child acts today will influence the way the child thinks tomorrow. A child gains knowledge continuously about which strategies are effective and which are not. Based on this knowledge, a child can adopt and modify strategies in the future. This process is continuous and therefore is not an age-defined process like the transition from concrete operations to formal operations in Piaget's theory (Siegler, 1991).

The final assumption is that task analyses are critical to understanding thinking because how individuals represent and process information is based largely on the task the individuals are performing. An individual's actions may look irrational unless the actions are studied in conjunction with the task. By studying the task, it can be determined which processes are required by the task and what limitations the environment places on the individual. Then it can be determined whether the individual's actions are suitable to the task or due to the individual's inadequate information-processing capabilities (Siegler, 1991).

There are various information-processing theories and each one focuses on at least one of the four critical change processes: encoding, strategy construction, generalization, and automatization. These processes collaborate to cause considerable cognitive change. For example, to solve problems correctly, children must encode the information in the problem. Then they must combine this encoded information with prior knowledge in order to create a strategy for solving the problem. Generalization occurs when children apply their newly formed strategy to similar problems. Because new strategies are frequently slow to execute, they need to be practiced in order to maximize their effectiveness and become automatized (Siegler, 1991).

transfer

Information-processing theorists take one of two fundamental approaches to studying information processing: primarily a domain-general or a domain-specific approach. Domain-general theorists try to describe, in general terms, how we mentally process information. They want to show how general principles of information processing apply and are used across a variety of cognitive functions, from making perceptual judgments to understanding written text to reading maps to solving calculus problems. Most of these theories emphasize developmental changes in encoding, self-monitoring, and use of feedback. Domain-specific theorists emphasize the role of the development of competencies and knowledge in specific domains, arguing that most development is of this domain-specific kind.

In regard to encoding, as children grow older, they can encode more fully many features of their environment, and they can organize their encodings more effectively (e.g., Siegler, 1984, 1996; Sternberg, 1982, 1984). Across childhood, children can integrate and combine encoded information in more complex ways, forming more elaborate connections with what they already know (Siegler, 1984; Sternberg, 1984). In addition, older children simply know more than younger ones, and they can call on increasingly large stores of remembered information.

It has also been suggested that older children may have greater processing resources (Kail & Bisanz, 1992), such as attentional resources and working memory, than younger children, which may underlie their overall greater speed of cognitive processing. According to this view, the reason that older children seem able to process information more quickly than younger children may be because the older children can hold more information for active processing. Hence, in addition to being able to organize information into increasingly large and complex chunks, older children may be able to hold more chunks of information in their working memories.

Metacognitive Skills

It appears that as children grow older, they develop and use metamemory skills and various other kinds of *metacognitive skills* (involving the understanding and control of cognitive processes), such as monitoring and modifying their own cognitive processes, while they are engaged in tackling cognitive tasks (Brown, 1978; Flavell & Wellman, 1977; Flavell, Green, & Flavell, 1995). Many cognitive researchers have been interested in the specific metacognitive skills of older children.

One illustration of cognitive research is work on the understanding of appearance and reality. For example, 4- and 5-year-old children were shown imitation objects such as a sponge that looked exactly like a rock (Flavell, Flavell, & Green, 1983). The researchers encouraged the children to play with the imitations, so that the children would become familiar with the objects and understand that the imitations were not what they appeared to be. Children then had to answer questions about the identities of the objects. Afterward, the children were asked to view the objects through a blue plastic sheet, which distorted the perceived hues of the objects, and to make color judgments about the objects. The children were also asked to view the objects through a magnifying glass and to make size judgments about them. The children were fully aware that they were viewing the objects through these intermediaries. The children's errors formed an interesting pattern. The children made two fundamental kinds of errors. On the one hand, when asked to report reality (the way an object actually was), the children would sometimes report appearance (the way the object looked through the blue plastic or the magnifying glass). Conversely, when asked to report appearance, they would sometimes report the reality. In other words, 4- and 5-year-old children did not yet clearly perceive the distinction between appearance and reality.

Actually, many Piagetians would agree with the observation that young children often fail to distinguish appearance from reality; children's failure to conserve quantity may also be attributed to their attention to the change in appearance, rather than to the stability of the quantity. Children also profit from and eventually even seek out feedback regarding the outcomes of their cognitive efforts. These changes in encoding, memory organization and storage, metacognition, and use of feedback seem to affect children's cognitive development across many specific domains. In addition, however, some cognitive-developmental changes seem to be domain-specific.

Memory Development

The use of external memory aids, of rehearsal, and of many other memory strategies seems to come naturally to almost all of us as adults—so much so that we may take for granted that we have always done it. In fact, we have not. Appel et al. (1972) designed an experiment to discover the extent to which young children spontaneously rehearse. They showed colored pictures of common objects to children at three grade levels: preschoolers, first-graders, and fifth-graders. Children were instructed either to "look at" the names of 15 pictures or to "remember" the names for a later test. When children were instructed just to look at the pictures, almost none exhibited rehearsal. In the memory condition, some of the young children showed some—but not much—rehearsal. Very few of the preschoolers seemed to know that it would be a good idea to rehearse when they would later be asked to recall information. Moreover, the performance of the preschoolers was no better in the memory condition than in the looking condition.

Older children performed better. On the basis of these and other data, Flavell and Wellman (1977) concluded that the major difference between the memory of younger and older children (as well as adults) is not in basic mechanisms, but in learned strategies, such as rehearsal. Young children seriously overestimate their ability to recall information, and they rarely spontaneously use rehearsal strategies when asked to recall items. That is, young children seem not to know about many memory-enhancing strategies.

In addition, even when young children do know about such strategies, they do not always use them. For example, even when trained to use rehearsal strategies in one task, most do not *transfer* the use of that strategy, carrying over their learning from one task to other tasks (Flavell & Wellman, 1977). Thus, it appears that young children lack not only the knowledge of strategies but also the inclination to use them when they do know about them. Older children understand that to retain words in short-term memory, they need to rehearse; younger children do not. In a nutshell, younger children lack metamemory skills.

Whether children rehearse is not just a function of age. Brown and colleagues (Brown, Campione, Bray, & Wilcox, 1973) found that mentally retarded children are much less likely to rehearse spontaneously than are children of normal intelligence. Indeed, if such children are trained to rehearse, their performance can be greatly improved (Belmont & Butterfield, 1971; Butterfield, Wambold, & Belmont, 1973). However, the performers who are mentally retarded will not always spontaneously transfer their learning to other tasks. For example, if the children are taught to rehearse with lists of numbers but then are presented with a list of animals, they may have to be taught all over again to rehearse for the new kinds of items, as well as for the old. The results of the studies on memory strategies combined with the results from studies that use a broad range of memory tasks (e.g., Knopf, Korkel, Schneider, & Weinert, 1988; Kurtz-Costes, Schneider, & Rupp, 1995; Weinert, Schneider, & Knopf, 1988), even in longitudinal designs (e.g., Schneider & Weinert, 1995; Weinert & Schneider, 1986, 1992), indicate that deliberate memory is domain-specific rather than domain-general.

Culture, experience, and environmental demands also affect the use of memory-enhancing strategies. For example, Western children, who generally have more formal schooling than non-Western children do, are given much more practice than are non-Western children in using rehearsal strategies for remembering isolated bits of information. In contrast, Guatemalan children and Australian aboriginal children generally have many more opportunities to become adept at using memory-enhancing strategies that rely on spatial location and arrangements of objects (Kearins, 1981; Rogoff, 1986).

Another aspect of metamemory skill involves *cognitive monitoring,* in which the individual tracks and, as needed, readjusts an ongoing train of thought. Cognitive monitoring may consist of several related skills (Brown, 1978; see also Brown & DeLoache, 1978). For one thing, people learn to realize what they know and what they do not know (Brown, 1978). People also learn to be aware of their mind and the degree of their understanding (Holt, 1964). More recent work on the development of cognitive monitoring proposes a distinction between self-monitoring and self-regulation strategies (Nelson & Narens, 1994). Self-monitoring is a bottom-up process of keeping track of current understanding, involving the improving ability to predict memory and related performance accurately. Self-regulation is a top-down process of central executive control over planning and evaluation. Children benefit from training in using cognitive monitoring processes to enhance their use of appropriate strategies (see Schneider & Bjorklund, 1998).

Physiological maturation of the brain and increasing content knowledge may partially explain why adults and older children generally perform better on memory tests than do younger children. These physiological and experience-based changes augment changes in memory processes, such as increased knowledge about and inclination to use metamemory strategies. The goal of such strategies is eventually to be able to retrieve stored information, at will.

Quantitative Skills

Some researchers believe biological influences govern basic computational abilities, such as numerosity (i.e., determining the number of objects without counting), ordinality (i.e., relative quantities—more, less, larger, smaller, etc.), counting, conservation or number, and simple arithmetic because these abilities emerge spontaneously in children everywhere (Bisanz, Morrison, & Dunn, 1995; Gallistel & Gelman, 1992; Geary, 1993, 1996; Wynn, 1992). R. Gelman and Gallistel (1978; Gallistel & Gelman, 1992) suggested that preschoolers' counting is governed by five implicit principles: one-to-one correspondence, stable order, cardinality, abstraction, and order irrelevance. Other researchers have suggested that children first use basic abilities (e.g., counting) before developing a conceptual representation of their activity (Briars & Siegler, 1984; Siegler & Jenkins, 1989; Siegler & Shrager, 1984).

Children's counting knowledge is related to their skill in using computational strategies to solve arithmetic problems (Geary, Bow-Thomas, & Yao, 1992). Consider, for example, the addition problem, "2 + 3 = ?" Several different information-processing models have been proposed regarding how children solve problems of this kind (e.g., Groen & Parkman, 1972; Suppes & Groen, 1967; subtraction problems also have been studied by Woods, Resnick, & Groen, 1975, and by Siegler & Shrager, 1984). Early models described some type of mental counter that starts at some value (determined by the addition problem) and then adds increments as needed (also determined by the addition problem). Before each *increment* (i.e., addition of one unit), a mental test counts whether the child has already added the needed number of increments. If so, the incremental process stops, and the child has reached the answer. If not, the child adds increments one by one until the required number of increments (in this case, three) have been added.

Siegler's model (1991; Siegler & Shrager, 1984) enhances the early models by adding a second major component to the process. Specifically, once children encode the problem, they first attempt to retrieve a potential correct answer from memory. If the answer they retrieve exceeds their own preset level of confidence in the accuracy of the answer, they state the retrieved answer. If it does not, they again try to retrieve a correct answer from memory. They repeat this process until either they retrieve a satisfactory answer that exceeds their confidence level or they exceed a preset number of retrieval attempts. If they exceed their preset number of retrieval attempts, they then turn to a *backup strategy* (a more time-consuming but more reliable way of reaching an answer, used when faster methods fail to produce satisfactory results). For addition problems, this backup strategy is the incremental counter mentioned in other models. Siegler has also applied the strategy-choice (retrieval-backup) model to children's other arithmetic computations, such as multiplication (Siegler, 1988).

In a review of the literature pertaining to development of mathematical skills, Ginsburg (1996) proposed various basic principles of mathematical learning. Here, we discuss a few key ideas to remember about quantitative skill development. First, even infants have some fundamental notion of quantity within the range of smaller numbers. Prelinguistic infants seem to know that adding leads to greater quantities and subtracting leaves smaller quantities. Moreover, young children appear to build on this fundamental knowledge to apply more abstract mathematical concepts in counting and to reason about addition and subtraction. Not only do children use the counting and memorization strategies previously discussed, but children also derive abstract rules from experience with particular kinds of counting sets. For example, rule learning combined with practice in counting by fives allows children to acquire multiplication principles more easily (Baroody, 1995). Finally, context effects, from problem wording to cultural environment, greatly influence mathematical learning beyond the formulation of informal strategies.

Inductive Reasoning

Inductive reasoning is the ability to induce a general rule, pattern, or schema from a series of instances, examples, or events, and then to apply that schema to predict a new event (Holland, Holyoak, Nisbett, & Thagard, 1986; Holyoak & Thagard, 1997; Johnson-Laird, 1993). Most inductive-reasoning problems center around forms of classification, series completion, or analogy. This type of reasoning does not lead to a single, logically certain solution to a problem, but only to solutions that have different levels of plausibility. In inductive reasoning, the reasoner induces general principles, based on specific observations. Carey (1985) did extensive work in observing inductive reasoning in children and has observed some developmental trends. For one thing, it appears that 4-year-olds do not induce generalized biological principles about animals when given specific information about individual animals. By age 10 years, however, children are much more likely to do so. For example, if 4-year-olds are told that both dogs and bees have a particular body organ, they still assume that only animals that are highly similar either to dogs or to bees have this organ and that other animals do not. In contrast, 10-year-olds would induce that if animals as dissimilar as dogs and bees have this organ, many other animals are likely to have this organ as well. Also, 10-year-olds would be much more likely than 4-year-olds to induce biological principles that link humans to other animals. Along the same lines, when 5-year-olds learn new information about a specific kind of animal, they seem to add the information to their existing schemas for the particular kind of animal but not to modify their overall schemas for animals or for biology as a whole (see Keil, 1989). At the same time, first and second graders have shown an ability to choose and even spontaneously to generate appropriate tests for gathering indirect evidence to confirm or disconfirm alternative hypotheses (Sodian, Zaitchik, & Carey, 1991).

S. A. Gelman (1985; S. A. Gelman & Markman, 1987) noted that even children as young as 3 years old seem to induce some general principles from specific observations, particularly those principles that pertain to taxonomic categories for animals. For example, preschoolers were able to induce principles that correctly attribute the cause of phenomena (such as growth) to natural processes rather than to human intervention (S. A. Gelman & Kremer, 1991; Hickling & Gelman, 1995). In related work, preschoolers were able to reason correctly that a blackbird was more likely to behave like a flamingo than like a bat because blackbirds and flamingos are both birds (S. A. Gelman & Markman, 1987). Note that in this example, preschoolers are going against their perception that blackbirds look more like bats than like flamingos. Instead, they base their judgments on the fact that blackbirds and flamingos are both birds (although the effect is admittedly strongest when the term *bird* is also used in regard to both the flamingo and the blackbird).

Other work by S. A. Gelman (S. A. Gelman & Markman, 1986) supports the view that preschoolers may make decisions based on induced general principles rather than on perceptual appearances—for example, they may induce taxonomic categories based on functions (such as means of breathing) rather than on perceptual appearances (such as apparent weight). When given information about the internal parts of objects in one category, preschoolers also induced that other objects in the same category were likely to have the same internal parts (S. A. Gelman & O'Reilly, 1988; see also S. A. Gelman & Wellman, 1991). On the other hand, when inducing principles from discrete information, young preschoolers were more likely than older children to emphasize external, superficial features of animals than to give weight to internal structural or functional features. Also, given the same specific information, older children seem to induce richer inferences regarding biological properties than do younger children (S. A. Gelman, 1989).

In a more recent review, Wellman and Gelman (1998) stressed the importance of maintaining both forms of knowledge—appearance-based and principled—for flexible use across different situations and domains. Knowledge about deep internal functional relations is important for inducing properties of objects, but similarity in appearance is also important under other circumstances. Wellman and Gelman propose that knowledge acquisition develops via the use of framework theories, or models, for drawing inferences about the environment in various domains (such as physics, psychology, and biology). Wellman and Gelman cite numerous studies demonstrating children's early and rapid acquisition of expertise in understanding physical objects and causal relations between events, psychological entities and causal-explanatory reasoning, and biological entities and forces. The changes in reasoning about factors in these domains appear to show enhanced understanding of the relation between appearances and deeper functional principles. Thus, children use foundational knowledge within different domains to build framework understandings of the world.

To summarize these findings, it appears that, once again, early developmental psychologists may have underestimated the cognitive capabilities of young children. In addition, a supportive context for induction can greatly enhance children's ability to induce appropriate principles (Keil, 1989). Nonetheless, there does appear to be a developmental trend toward increasing sophistication in inducing general principles from specific information and toward increasing reliance on more subtle features of the information on which such inductions are based. Furthermore, this sophisticated knowledge may be organized into general frameworks for understanding within the important domains of physics, biology, and psychology, which is discussed next.

Naive Psychology

Children have the difficult task of making sense of the world. Because the world is full of mysterious things, children must use foundational knowledge to formulate naive theories about objects and events in their environment. For example, children construct naive theories about physical phenomena (e.g., air and masses)—naive physics—and biological phenomena (e.g., living versus nonliving things)—naive biology. Here, we concentrate on naive psychology, which children use to understand other people's psychological states and experiences, as well as their own. In the last 15 years, children's naive psychology, studied through theory-of-mind research, has become a hot research topic in cognitive development. Premack and Woodruff (1978) introduced the expression *theory of mind* in their study of whether chimpanzees could understand others' intentions. Since then, their construct has been applied as well to children.

A mature understanding of psychological states is referred to as a belief–desire system (D'Andrade, 1987; Fodor, 1987; Wellman, 1990). Our psychology is based on beliefs, desires, and actions. People perform intentional actions because they believe that those actions will satisfy specific desires. For instance, why did June go to the ice cream store? She *wanted* an ice cream cone and *thought* she could buy one there. Besides beliefs and desires, related constructs, such as physiological states, conceptual experiences, and perceptual experiences, are also encompassed in naive psychology. In addition, the consequences of these actions lead to emotional experiences. Why did June go to the ice cream store? She *was hungry* and *remembered* that the store sold ice cream cones. Buying an ice cream cone made her *happy*. Preschoolers are able to explain simple actions in terms of a belief–desire framework (Bartsch & Wellman, 1989, 1995; Dunn & Brown, 1993; Wellman & Banerjee, 1991). For an exhaustive summary of preschoolers' additional naive psychology accomplishments, see Wellman and Gelman (1998).

Much of this research has focused on children's understanding of beliefs and, more specifically, false beliefs (e.g., Beth believes it is lunchtime, but it is not). When questioned about a simple situation involving a false belief, 4- and 5-year-olds are able to understand how the false belief violates reality. There are two notable tests of this competency: the standard false-belief task and the Smarties task. Wellman (1988) has called the false-belief task the "litmus test" of children's belief–desire system because it assesses their understanding of other's beliefs.

In the standard task, a child watches a person witness where an object is hidden. The person leaves the room, and the object is moved to a new location. Four- and 5-year-olds can predict that the person, on return, will search the original location because the person falsely believes it is there (e.g., Moses & Flavell, 1990; Wimmer & Perner, 1983). In the Smarties task, a child is shown a familiar box and the child reports that it contains candy. When told that the box actually contains pencils, 4- and 5-year-olds predict that another person, who only sees the outside of the box, will falsely believe that it contains candy (Gopnik & Astington, 1988; Perner, Leekam, & Wimmer, 1987).

Although most 4-year-olds pass these tests, 3-year-olds tend to fail them. Three-year-olds consistently make the same error; they say unequivocally that the person will look in the current location or will think that the box contains pencils. One hypothesis is that there is a significant reorganization of children's naive psychologies between the ages of 2 and 5 years. According to this hypothesis, what changes is how children construe people's relations to the world. Young children believe that people relate directly to the world, and as the children age, they believe that people relate to the world through their representations of the world (Wellman & Gelman, 1998).

There are three alternate accounts to explain this psychological development: theory-theory, modular, and expertise. The first account, theory-theory, regards children as progressing from an early desire theory of mind (Wellman, 1990), a situational theory of mind (Perner, 1991), or a connections theory of mind (Flavell, 1988) to a representational theory. But these different theory-theory explanations have one thing in common, as noted by Gopnik and Wellman (1994). According to all of them, young children's understandings of naive psychology are theory-like in their explanation of human behavior. What are some of these naive psychological theories?

Three-year-olds are unable to attribute false beliefs to others and are also unable to understand their own false beliefs and mental states (Gopnik, 1993). In the beginning of their development, children understand desires and emotions but have no concept of beliefs. They move to understanding beliefs but continue to explain action solely in terms of other states. Finally, they incorporate beliefs into their explanations. This development resembles a process of theory change (Wellman & Gelman, 1998).

Consider now a second account. Leslie (1987, 1994) and Fodor (1983, 1992) support a nativist, modular account of theory of mind. Fodor contends that evolution has instilled in humans an understanding of naive psychology. An understanding of desires and beliefs is present from birth and requires little to no learning. There are several studies that show 3-year-olds passing the false-belief task by varying the task. Some examples include rephrasing the questions (Lewis & Osborne, 1990; Siegal & Beattie, 1991), varying the salience of reality or mental states (Mitchell & Lacohee, 1991; Woolley, 1995; Zaitchik, 1991), reviewing the narrative (Lewis, Freeman, Hagestadt, & Douglas, 1994), and increasing the child's involvement in the deception (Chandler, Fritz, & Hala, 1989; Sullivan & Winner, 1993).

Consider finally a third account. Still other theorists propose that understanding beliefs involves expertise (e.g., Dunn, Brown, & Beardsall, 1991; Harris, 1992; Siegal, 1991; Stein & Trabasso, 1982). According to this account, experience and the development of a kind of expertise are necessary because children need to learn to override their own mental states and their own situations in order not to attribute their own mental states to others. Instead, children need to learn to induce others' mental states from information about the others' particular situations.

It is difficult empirically to test these three accounts. Although all three accounts recognize that children's performance on false-belief tasks change with age, they each advance different explanations of that change (Wellman & Gelman, 1998).

Further research has suggested a link between performance on false-belief tasks and other factors. Dunn, Brown, Slomkowski, Tesla, and Youngblade (1991) found a significant correlation between parents and children discussing feelings when the children were 33 months and the children's performance on false-belief tasks at 40 months. Preschoolers who have more siblings with whom they can interact also perform better than those who have fewer or no siblings (Jenkins & Astington, 1996; Perner, Ruffman, & Leekam, 1994). Perner, Ruffman, and Leekam (1994) contended that this finding indicates a socioexperimental explanation of theory-of-mind development over a maturationist explanation.

Leslie (1987, 1994) suggested a connection between theory of mind and pretend play. The ability to understand pretense, false belief, and other mental states are associated by a shared, early maturing metarepresentational capacity, termed a theory-of-mind mechanism (ToMM; for further details, see Leslie, 1987). For further research on theory of mind and pretense, see Astington (1993), Harris (1994), Harris, Lillard, and Perner (1994), Lillard (1993a, 1993b, 1994), Perner (1991), and Taylor (1996). Additional research is needed to determine the implications of these recent findings.

CONCLUSIONS

Although many routes have been proposed to explain cognitive development, all of them lead to cognitive maturation in adulthood. With adulthood comes greater cognitive abilities such as greater memory capacity; the ability to understand other people's thoughts, beliefs, and desires; the enhanced ability to form mental representations; and superior reasoning skills.

In this chapter, we presented four prominent perspectives in the field of cognitive development. Each stresses different issues about what is important in children's cognitive development. Piaget believed that it is necessary for a person to move successfully though all four developmental stages, thereby developing sensorimotor skills and concrete and formal operations. One main aspect of his theory is that a person develops cognitively by being able to process and integrate novel and relevant stimuli from one's environment. Although much of Piaget's work was done more than 50 years ago, Piaget's accomplishments continue to be important in current research, and his theory continues to be the most comprehensive theory of cognitive development. Although some of his claims have been disputed or even invalidated, the methods he used and the questions he raised in his work have directed recent research in cognitive development.

Because neo-Piagetian theorists exist in response to shortcomings in Piaget's theory, they consider much of the same issues to be important as Piaget did. Fifth-stage theorists, for the most part, maintain Piaget's theory but believe it needs an additional stage. Case also uses developmental stages as his foundation, but he characterizes his stages by the types of mental representations children can form and the types of responses they give at each stage. Fischer also bases his theory on stages, but contends that changes in cognitive development reflect changes in the organization of behavior. He also places more emphasis on specific experiences than do Piaget and Case.

Vygotsky's theory stands apart from the theories of Piaget and neo-Piagetians. Piaget believed that cognitive development proceeds largely "from the inside out" through maturation and emphasized the biological aspect of development. In contrast, Vygotsky's theory takes an entirely different approach in emphasizing the role of the environment and social interaction in children's cognitive development. He believed that children learn from the absorption of knowledge from context and through interactive learning.

We also discussed cognitive approaches. Among these is the information-processing approach. This also differs from the theories of Piaget and neo-Piagetians in that this approach is not centered around developmental stages but instead focuses on the operations of the mind. Information-processing theorists see the mind as a complex system that manipulates information that enters or is currently stored in it. They attempt to explain cognitive development in terms of how people of different ages process information. Neo-Piagetian and information-processing theories greatly elaborate on the theorizing of Piaget—providing details of performance that Piaget did not specify—and show that Piaget's model applied more to ideal competencies than to everyday performances. All of these theories of cognitive development contribute to the ongoing process of understanding how and why we humans think as we do.

The preceding cognitive-developmental perspectives are not mutually exclusive; some have been pursued simultaneously, others have evolved as reactions to earlier perspectives, and still others are offshoots of earlier perspectives. These perspectives, as exhaustive as they are, still do not account for all aspects of cognitive development. Miller (1993) contended that the available theories share three weaknesses: overly narrow scope, uncertain ecological validity, and inadequate accounts of developmental mechanisms. Of the three, the greatest weakness appears to be their inadequate accounts of developmental mechanisms. A better account of the mechanisms would allow an understanding of the other two weaknesses (Siegler, 1996). More important, it would lead to a more comprehensive picture of the emergence of cognitive abilities.

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