THE PREOPERATIONAL PERIOD (ROUGHLY 2 YEARS TO 6 OR 7 YEARS)

Miller (1993) nicely captured children’s position as they complete the sensorimotor period by likening them to mountain climbers who, after a hard trek, discover that what they have climbed is merely a foothill to Mt. Everest. By the end of the sensorimotor stage, infants have become toddlers. They interact smoothly with objects and people in their immediate environment. Their ability to form internal representations remains severely limited, however. The growth of representational ability is the key development of the preoperational period.

*Early symbolic representations.* Piaget suggested that the earliest sign of internal representations is deferred imitation, the imitation of an activity hours or days after it occurred. For children to show such delayed imitation, they must have formed a durable representation of the original activity. How else could they imitate it so much later?

Children do not exhibit deferred imitation until late in the sensorimotor period. Consider the following description of Piaget’s daughter Jacqueline kicking and screaming in her playpen.

At 1;4(3) [Piaget’s notation for 1 year, 4 months, and 3 days] Jacqueline had a visit from a little boy of 1;6 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. (Piaget, 1951, p. 63)

Jacqueline had never before, to her father’s knowledge, engaged in these behaviors. Thus, an internal representation of the playmate’s tantrum must have helped her reproduce them.

Piaget distinguished between two types of internal representations: symbols and signs. The distinction is not identical to the standard English distinction between the two. Rather, it is the difference between idiosyncratic representations intended only for one’s personal use (symbols) and conventional representations intended for communication (signs).

Early in their acquisition of internal representations, children frequently use symbols (the personal representations). They may choose a particular piece of cloth to represent their pillow or a popsicle stick to represent a gun. Typically, these personal symbols physically resemble the object they represent. The cloth’s texture is similar to that of the pillow, and both are comforting; the popsicle stick’s shape and texture are something like those of a gun barrel. Signs, by contrast, often do not resemble the objects or events they signify. The word *cow* does not look like a cow, nor does the numeral *6* have any inherent similarity to six objects.
As children develop, they make less use of the idiosyncratic symbols and more of the conventional signs. This shift is an important achievement, as it greatly expands their ability to communicate. The transition from personal to publicly accepted representations is not easy, however.

The difficulty is illustrated in Piaget’s description of egocentric communication. Piaget applied the term “egocentric” to preschool-age children, not to castigate them for being inconsiderate, but rather in a more literal sense. Their thinking about the external world is always in terms of their own perspective. Their use of language reflects this egocentrism, particularly their use of idiosyncratic words that are meaningless to other people.

Although even very young children use signs as well as symbols, they at first do not use them consistently in a manner that other people can understand. Figure 2.2 portrays an instance of this aspect of young children’s conversations. Preschoolers often speak right past each other, without appearing to pay any attention to what others are saying. Many times, even sympathetic adults cannot figure out what the children mean.

Between ages 4 and 7 years, speech becomes less egocentric. One of the earliest signs of progress can be seen in children’s verbal quarrels. The fact that a child’s verbal statements elicit a playmate’s disagreement indicates that the playmate is at least paying attention to a perspective other than his own. Some children also are aware of the symbolization process and find it interesting in its own right. When Siegler’s daughter was 4, she took great delight in saying such things as, “When I say ‘chair,’ I’m going to mean ‘milk’; could you give me a glass of chair?”

Piaget noted that mental imagery, like language, is a way of representing objects and events. He also suggested that the development of mental imagery resembles that of language. As children become able to describe situations

![Image](image-url)
verbally, they also become able to represent them as images. Further, he believed that the initial representations in both domains are limited to the child’s own perspective. That is, they are egocentric.

Although language, mental imagery, and many other skills grow greatly during the preoperational period, Piaget emphasized what preoperational children cannot do. He viewed them as unable to solve many problems that are critical indicators of logical reasoning. Even the name, "preoperational," suggests deficiencies rather than strengths.

One of the limits on preschoolers’ thinking has already been mentioned: their egocentrism. This trait is evident not only in their conversations, but also in their ability to take different spatial perspectives. Piaget had 4-year-olds sit or stand at a table in front of a model of three mountains of different sizes (Figure 2.3). The children’s task was to choose which of several photographs corresponded to what children sitting at chairs at different points around the table would see. To solve the problem, children needed to recognize that their own perspective was not the only one possible and to mentally rotate the arrangement they saw to correspond to what the view would be elsewhere. This was impossible for most of the 4-year-olds; they could not imagine the view from other positions.

A second, related limit on preschoolers’ thinking is that it centers on individual, perceptually striking features of objects, to the exclusion of other, less striking features. A good example of this centration is found in Piaget’s research on children’s understanding of the concept of time.

Piaget’s interest in this concept has an interesting history. In 1928, Albert Einstein posed a seemingly simple question to Piaget: In what order do children acquire the concepts of time and velocity? Einstein’s question was prompted by an issue within physics. In Newtonian theory, time is a basic quality and velocity is defined in terms of it (velocity = distance/time). Within relativity theory, in contrast, time and velocity are defined in terms of each other, with neither concept more basic. Einstein wanted to know whether understanding of either or both concepts was present from birth or if children understood one before the other.

FIGURE 2.3 The three-mountains problem. The child’s task is to indicate how the display would look to someone viewing it from a perspective other than her own (after Piaget & Inhelder, 1969).
Almost 20 years later, Piaget (1946a, 1946b) published a two-volume, five hundred-page reply to Einstein's question. The gist of Piaget's answer was that mastery of all three concepts emerged simultaneously during the concrete operations period.

To test this view, Piaget presented a task involving two toy trains running along parallel tracks in the same direction. After the cars stopped moving, Piaget asked, "Which train traveled for the longer time (or the faster speed, or the farther distance)?" Most 4- and 5-year-olds focused entirely on a single feature, usually the stopping point. They chose the train that stopped farther down the track as having traveled faster, for the longer time, and for the greater distance. Stated differently, they ignored when the trains started, when they stopped, and the total time for which they traveled. Not until roughly age 9 did they answer correctly.

The example illustrates another of the basic qualities of children's thinking in the preoperational period. They tend to focus on static states rather than transformations. The point where each train ended constitutes a static position, readily perceivable and available for repeated inspection. The time, speed, and distance traveled are more transitory. The dimensions on which preoperational period children focus usually are static states; the dimensions they ignore usually involve transformations.

Thus, Piaget viewed 2- to 6-year-olds as having difficulty taking perspectives other than their own, as paying too much attention to perceptually salient dimensions and ignoring less salient ones, and as representing static states but not transformations. All of these descriptions suggest that such young children think about the world too simply and rigidly. They largely surmount these limitations in the next period of development.

**The Concrete Operations Period (Roughly 6 or 7 Years to 11 or 12 Years)**

The central development in the concrete operations period is the acquisition of operations. These operations are mental representations of dynamic as well as static aspects of the environment. All development up to this time has been a prelude to this achievement. In the sensorimotor period, children learned to operate physically on the environment. In the preoperational period, they learned to mentally represent static states. Finally, in the concrete operations period, they become able to represent transformations as well as static states.

The importance of operations can most easily be illustrated in the context of conservation problems. Consider children's understanding of three types of conservation: liquid quantity, solid quantity, and number. Although these conservation problems differ among themselves in certain respects, all share a basic three-phase procedure (Figure 2.4). In the first phase, children see two or more identical objects or sets of objects: two identical rows of checkers, two identical glasses of water, two identical clay cylinders, and so on. Once the children agree
that the two are equal on some dimension, such as the number of objects, the second phase begins. Here, one object or set of objects is transformed in a way that changes its appearance but does not affect the dimension of interest. Children might see the row of checkers lengthened, the water poured into a differently-shaped glass, the clay cylinder remolded into a ball, and so on. Finally, in the third phase, children are asked whether the dimension of interest, which they earlier said was equal for the two choices, remains equal following the transformation of one of them. The correct answer invariably is "yes."

These problems seem trivially easy to adults and older children. However, almost all 5-year-olds answer them incorrectly. On number conservation problems, they claim that the longer row has more checkers (regardless of the actual numbers in each row). On conservation of liquid quantity problems, they claim that the glass with the taller column of liquid has more (regardless of the cross-sectional areas of the glasses). On conservation of solid quantity problems, they believe that the longer sausage has more clay (again regardless of the cross-sectional areas).
Considering what children need to do to solve conservation problems makes the 5-year-olds' difficulty understandable. They must mentally represent the spreading, pouring, or remolding transformation involved in the problem. They also must not focus all their attention on the perceptually salient dimension of height or length; they need to consider cross-sectional area and density as well. Finally, they need to realize that even though the transformed object may seem to have more of the dimension in question, it might not. That is, they need to understand that their own perspective can be misleading. Each of these is difficult for 5-year-olds to do.

In the concrete operations stage, children master all three conservation problems. They also master the train problem that was used to measure understanding of time, distance, and velocity. Piaget explained their mastery of these and many other concepts in terms of the children's now possessing mental operations. These operations allow them to represent transformations as well as static states.

Children's explanations of their reasoning on conservation problems are especially revealing. When 5-year-olds are asked to explain why the amount of water has changed, they regularly say that the water in the new glass is higher. When 8-year-olds are asked to explain why the amount of water remains the same, they point to the nature of the transformation ("You just poured it"), to changes in the less striking dimension offsetting the changes in the more striking one ("The water in this one is taller, but the water in that one is wider"), to the water looking different but really being the same, and to the reversible nature of the operation ("You could pour it back and it would be the same"). Interestingly, 5-year-olds will grant many of these points, but do not see them as implying that the two glasses have the same amount of water.

Although children in the concrete operations period become capable of solving many problems, certain types of abstract reasoning remain beyond them. Some of these problems require reasoning about propositions that are contrary to fact ("If people could know the future, would they be happier than they are now?"). Others involve treating their own thinking as something to be thought about. To quote one adolescent, "I was thinking about my future, and then I began to wonder why I was thinking about my future, and then I began to think about why I was thinking about why I was thinking about my future" (Mussen, Conger, Kagan, & Geiwitz, 1979). Still others involve thinking about abstract scientific concepts such as force, inertia, torque, and acceleration. These types of ideas become possible in the formal operations period.

**THE FORMAL OPERATIONS PERIOD (ROUGHLY 11 OR 12 YEARS ONWARD)**

Perhaps the most striking development during the formal operations period is that adolescents begin to see the particular reality in which they live as only one of an infinite number of imaginable realities. This leads at least some of them to
think about alternative organizations of the world and about deep questions concerning meaning, truth, justice, and morality. As Inhelder and Piaget (1958) put it, "Each one has his own ideas (and usually he believes they are his own) which liberate him from childhood and allow him to place himself as the equal of adults" (pp. 340–341). From this perspective, it is no coincidence that many people first acquire a taste for science fiction during adolescence.

Many of the differences between formal and concrete operational reasoners are evident in Inhelder and Piaget’s (1958) descriptions of children’s and adolescents’ approaches to the chemical combinations problem. The task involved four beakers, each with a particular chemical solution, and a "special" beaker with an unknown mixture of one or more of the other chemicals in it. When another chemical was added to the special beaker, the solution turned yellow. The children were asked to determine which of the four chemicals were in the solution that turned yellow and what role each played.

Concrete operational children typically generated several pairs of the chemicals, then tried all four together, and then generated a few of the possible sets of three. They often repeated combinations they already had tried and left out other combinations altogether. In contrast, formal operational children first devised a plan for systematically generating all possible combinations of the chemicals. Then they used their plan to generate each combination without redundancies or omissions.

The formal operational reasoners’ more systematic approach also helped them draw a more appropriate conclusion about when and why the yellow color appeared. Concrete operations children often stopped collecting evidence after they found a single combination that turned the solution yellow. They concluded that it must have been the original solution and that all chemicals in it were necessary for the reaction to occur. In contrast, formal operations children, who tried all possible combinations, eventually learned that two different combinations produced the yellow color. What these combinations had in common was the presence of two of the chemicals and the absence of a third. (The absence of the third chemical was what distinguished the two instances that did turn yellow from two others that had both necessary chemicals in them but that did not turn yellow.) Therefore, the formal operational reasoners reached the correct conclusion that two of the chemicals were necessary to produce the change in color, that a third would prevent it from happening even if the first two were present, and that the fourth had no effect. Their focusing on the system of possible combinations allowed them to obtain the relevant data and to interpret it appropriately.

Some of the largest changes in thinking during the formal operations period involve logical and scientific reasoning (Moshman, 1998). The abstract and systematic thinking that develop especially greatly during the formal operations period are particularly crucial in such contexts. Scientific and logical reasoning problems often require applying the most abstract ways of thinking to the most challenging problems. Not surprisingly, Piaget viewed such formal operations as
the culmination of the process of cognitive development, the fruition of all that had developed before.

The Development of Some Critical Concepts

The broad sweep of Piaget’s descriptions of children’s thinking emerges most clearly in his accounts of the development of particular concepts. Some concepts for which his descriptions are especially interesting are conservation, classes, and relations. He traced the development of each of these from their earliest origins in the sensorimotor period, through more refined versions in the preoperational and concrete operational periods, to the most sophisticated understandings in the formal operations period. People do not usually think of infants’ thinking as having anything to do with that of teenagers. Part of Piaget’s genius was that he saw the connection.

Conservation

Conservation in the sensorimotor period. During the sensorimotor period, children acquire a simple but crucial part of the conservation concept. This might be labeled “conservation of existence,” though Piaget called it object permanence. Adults know that objects do not just disappear from the world (although they sometimes seem to). If we want a ball and it rolls behind another object, we search for it and remove barriers if necessary to get it. Piaget observed that infants younger than 8 months do not search like this; they simply turn their attention to something else. He did not attribute this to their losing interest or being too poorly coordinated to retrieve the object. Instead, he advanced the more radical view that they did not understand that the objects still existed. He further argued that full understanding of object permanence required the entire sensorimotor period.

In Substage 1, from birth to 1 month, infants look at objects directly in front of them. However, if an object moves away, they do not follow it with their eyes. Thus, an infant will look at her mother’s face when it is directly above, but will stop looking if the mother moves aside. In Substage 2, between 1 and 4 months, infants prolong their looking at the place where an object disappeared, but do not follow its movement. If they are playing with a toy and drop it, they continue looking at their hand rather than at the floor. In Substage 3, between about 4 and 8 months, they anticipate where moving objects will go, and look for them there if they are partially visible. However, if the object is completely covered, they do not attempt to retrieve it (as illustrated in the quotation at the beginning of this chapter).

In Substage 4, between 8 and 12 months, infants begin to search for objects behind or under barriers. This indicates that they realize that objects have a permanent existence. Under certain circumstances, however, 8- to 12-month-olds
make an interesting mistake. If they see an object hidden twice in succession under the same container, they retrieve the object from there each time. If they then see the same object hidden under a different container, however, they look under the container where they found it before, rather than under the one where it is now. It is as if this original container had assumed an independent status as a hiding place where the object can be found. This error has been termed the “A-not-B” error.

In Substage 5, roughly between 12 and 18 months, infants stop making the A-not-B error and search wherever they last saw the object hidden. However, they remain unable to deal efficiently with transformations in which the desired object cannot be directly perceived. When a toy is first hidden under a cover, and then the toy and cover together are hidden under a pillow, and then the cover is removed so that the toy remains under the pillow, 12- to 18-month-olds do not look under the pillow. By Substage 6, however, between 18 and 24 months, babies understand even this type of complex displacement and immediately search in the right place.

At first glance, Piaget’s account of object permanence may seem extremely improbable. It may seem more likely that the infants younger than 8 months fail to search for objects either because they are not sufficiently well coordinated to do so or because they quickly lose interest in the objects. An experiment by Bower and Wishart (1972), however, rendered unlikely both of these possibilities. Five-month-olds saw a toy hidden under a transparent cup. The large majority of infants retrieved it. Then the infants saw the same toy hidden under an opaque cup. Only 2 of 16 retrieved it. This experiment ruled out both motoric immaturity and lack of motivation as explanations for the infants’ failure to search under the opaque cup. If they lacked sufficient interest in the toy to retrieve it, or failed because they lacked the necessary coordination, why were they interested and coordinated enough to retrieve the same object when it was hidden under the transparent cup?

Conservation in the preoperational and concrete operational periods. In the sensorimotor period, infants come to realize that the existence of objects is conserved over certain types of transformations, specifically, ones in which the object is hidden. In the preoperational and concrete operational periods, children come to realize that certain qualities of objects also are conserved even when transformations change their appearance. Spreading out objects increases the length of the row but leaves unchanged the number of objects. Pouring water from a typical glass to a taller, thinner one changes the height of the liquid column but leaves unchanged the amount of water. By the end of the concrete operational period, children realize that even when transformations alter appearances, a great many tangible dimensions are conserved: number, amount, length, weight, area, and so on.

Conservation in the formal operational period. During the formal operations period, adolescents come to understand complex forms of conservation
that involve transformations of transformations. One such concept is conservation of motion. Inhelder and Piaget (1958) studied children's and adolescents' understanding of this concept by presenting them with a spring-powered plunger that shot balls of various sizes. The task was to predict where the balls would stop, to explain why some balls stop earlier than others, and to explain why balls stop at all.

Performance on this problem at various ages illustrates the types of reasoning that Piaget thought were fundamental at those ages. Preoperational children focus on only one dimension and take only one perspective. They might consistently predict that a big ball will go farther because it is stronger. Concrete operational children realize that multiple dimensions are important and take multiple perspectives. They might realize the importance of qualities of the surface on which the ball rolls, as well as of the ball itself. They also might recognize that the problem can be thought of in terms of what makes the ball stop, as well as what makes it go. Thus, they might believe that bigger balls go farther, but also that rougher surfaces lead to balls going less far.

By the formal operations period, children think of the problem in terms of sophisticated scientific concepts, such as conservation of motion. That is, they conceptualize the problem in idealized terms (“If there were no air resistance or friction . . .”). This way of thinking is a distinctive achievement of formal operations, because it involves conservation of a dimension—motion—that itself involves a transformation—movement through space. In addition, it illustrates how adolescents proceed from the actual to the possible, since no one has experienced an environment without air resistance or friction.

CLASSES AND RELATIONS

Another of Piaget's insights was seeing the connection between children's understanding of classes and relations. This connection can be illustrated with regard to numbers. What does it mean when we say that a girl understands the concept "three"? One part of the understanding is seeing what three balls, three cars, and three spoons have in common—that they are all members of the class of three-member sets. She also should understand the relation of this class to other classes—larger than sets with two members and smaller than sets with four. Piaget viewed children as originally thinking of classes and relations as separate ideas, but eventually integrating them into a unified understanding.

Understanding of classes and relations in the sensorimotor period. Piaget contended that infants classify objects according to the objects' functions. He illustrated this point by describing his daughter Lucienne's reaction to a plastic parrot that sat atop her bassinet. Lucienne liked to make the parrot move by kicking her feet while lying in the bassinet. At six months of age, she made similar kicking motions when she was out of the bassinet but still could see the
parrot. Piaget interpreted this as Lucienne classifying the parrot as “something that swings when I kick my feet.” Far more sophisticated categories are seen as evolving from such simple classifications.

Understanding of relations, like understanding of classes, is seen as developing out of sensorimotor actions. Piaget described his three children at 3 and 4 months as being greatly amused by the relation between the vigor of their actions and the strength of the reaction they produced. More vigorous kicking produced more vigorous swinging of objects on the bassinet; more vigorous shaking of a rattle produced louder noises; and so on. Thus, they understand the relation “the more vigorously I do something, the larger its effect.”

**Understanding of classes and relations in the preoperational period.** Children progress considerably in classificatory ability during the preoperational period. This progress is evident when they are asked to put together a group of blocks varying in size, color, and shape. Early in the preoperational period, a boy might try to put together all of the small objects, and therefore choose a small red square, then a small blue square, then a small red triangle. However, the fact that the last object was a triangle might grab his attention, leading him to add a large red triangle and a large green triangle, thus creating a group without any unifying characteristic. Not until later in the preoperational period, around age 4 or 5 years, do children come to classify on a consistent basis. At this point, they put all small objects into one group and all big ones into another.

Although children learn to solve this type of problem during the preoperational period, other classification problems remain difficult. The limitations of their reasoning are most evident when they simultaneously need to consider competing bases of classification, as in Piaget’s class inclusion problem. On such problems, children might be presented eight toy animals, six of them cats and two dogs. They then would be asked, “Are there more cats or more animals?” Most children below age 7 or 8 answer that there are more cats, despite the number of cats inherently being less than or equal to the number of animals.

Piaget saw this behavior as stemming from preoperational children’s tendency to focus on a single dimension to the exclusion of others. To solve the problem correctly, children need to keep in mind that an object (for example, Garfield) may simultaneously belong both to a subset (cats) and to a superset (animals). They find this difficult. Therefore, they reinterpret the question in a way that allows them to solve a problem that they do understand: whether there are more cats or more animals other than cats. This leads them to compare the number of cats to the number of dogs and thus to say that there are more cats than animals.

Children’s understanding of relations also grows considerably during the preoperational stage. However, their ability to focus on the relation that is relevant in the particular situation, and to screen out irrelevant ones, remains limited. To illustrate both the growth and the remaining deficiencies, Piaget (1952) presented to preoperational children the type of seriation problem shown in Figure 2.5. He asked them to arrange the sticks from shortest to longest in a
1. Early in the preoperational stage if asked to seriate

2. Later in the preoperational stage if asked to seriate

3. But, if asked to insert into

   children first try

   then try

   and so on.

FIGURE 2.5 Typical responses to seriation problems of children early and late in the preoperational stage.
single row. If they succeeded at this task, he presented them a second problem. Here they needed to insert a new stick of medium length at the appropriate point in the row they had made.

Early in the preoperational stage, between ages 2 and 4, children encounter great difficulty creating correct orderings. As in the first row of Figure 2.5, they might arrange two subsets of the sticks correctly, but not integrate the two into a single overall ordering. The shifting focus is similar to that shown when they first grouped together several small objects and then, after encountering a small triangle, started putting all triangles in the group.

Later in the preoperational stage, children can correctly order the lengths of the original set of sticks. However, they often fail to find the correct place to insert the additional stick without extensive trial and error. Piaget attributed this remaining difficulty to preoperational children’s difficulty in simultaneously viewing the new stick as smaller than one stick and larger than another quite similar in size.

**Understanding of classes and relations in the concrete operational period.** Piaget contended that in the concrete operational period, children come to treat classes and relations as a single, unified system. Their attempts to solve *multiple classification problems* illustrate this development. Consider the problem in Figure 2.6. Children see intersecting rows of stimuli that vary along two dimensions, in this case shape (square, circular, or oblong) and color (black, white, or gray). The task is to choose an object to put in the blank space so that all nine objects are ordered along the two dimensions. This requires identifying the two relevant classes (shape and color) and choosing an object that maintains the relations among objects already established within the rows and columns of the matrix.

Inhelder and Piaget (1964) reported that 4- to 6-year-olds selected objects that included at least one of the desired dimensions on 85 percent of problems. However, they chose the single object that included both desired dimensions on only 15 percent. By 9 or 10 years of age, the large majority of children choose the object that maintains both dimensions, revealing an ability to consider classes and relations together.

**Understanding of classes and relations in the formal operational period.** Formal operational reasoning enables adolescents to think about relations among relations and about classes of classes. For example, they might first divide the students in their high school into a number of classes (nerds, jocks, skaters, preps, druggies, etc.), and then construct higher-order classes of the groups whose members tend to be friends with each other (such as preps and jocks).

Formal operational reasoning also leads adolescents to interpret observed outcomes within the context of logically possible outcomes. This type of reasoning was illustrated in the description of the chemical combinations problem earlier in the chapter. Formal operational reasoners not only planned a way