chapter 5

MOTOR, SENSORY, AND PERCEPTUAL DEVELOPMENT

chapter **outline**

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preview

Think about what is required for us to find our way around our environment, to play sports, or to create art. These activities require both active perception and precisely timed motor actions. Neither innate, automatic movements nor simple sensations are enough to let us do the things we take for granted every day. How do we develop perceptual and motor abilities, and what happens to them as we age? In this chapter, we will focus first on the development of motor skills, then on sensory and perceptual development, and finally on the coupling of perceptual-motor skills.

Motor Development

LG1 Describe how motor skills develop

- The Dynamic Systems View
- Reflexes
- Gross Motor Skills
- Fine Motor Skills

Most adults are capable of coordinated, purposive actions of considerable skill, including driving a car, playing golf, and typing accurately on a computer keyboard. Some adults have extraordinary motor skills, such as those involved in winning an Olympic pole vault competition, painting a masterpiece, or performing heart surgery. Look all you want at a newborn infant, and you will observe nothing even remotely approaching these skilled actions. How, then, do the motor behaviors of adults come about?

Esther Thelen is shown conducting an experiment to discover how infants learn to control their arms to reach and grasp for objects. A computer device is used to monitor the infant's arm movements and to track muscle patterns. Thelen's research is conducted from a dynamic systems perspective. *What is the nature of this perspective?*

THE DYNAMIC SYSTEMS VIEW

Developmentalist Arnold Gesell (1934) thought his painstaking observations had revealed how people develop their motor skills. He had discovered that infants and children develop rolling, sitting, standing, and other motor skills in a fixed order and within specific time frames. These observations, said Gesell, show that motor development comes about through the unfolding of a genetic plan, or maturation.

Later studies, however, demonstrated that the sequence of developmental milestones is not as fixed as Gesell indicated and not due as much to heredity as Gesell argued (Adolph & Berger, 2013; Adolph & Robinson, 2013). In the last two decades, the study of motor development experienced a renaissance as psychologists acquired new insights about how motor skills develop (Thelen & Smith, 1998, 2006). One increasingly influential explanation is dynamic systems theory, proposed by Esther Thelen.

According to **dynamic systems theory,** infants assemble motor skills for perceiving and acting (Thelen & Smith, 2006). To develop motor skills, infants must perceive something in the environment that motivates them to act and then use their perceptions to fine-tune their movements. Motor skills represent pathways to the infant's goals (Keen, 2011).

How is a motor skill developed, according to this theory? When infants are motivated to do something, they might create a new motor behavior. The new behavior is the result of many converging factors: the development of the nervous system, the body's physical properties and its possibilities for movement, the goal the child is motivated to reach, and the environmental support for the skill. For example, babies learn to walk only when maturation of the nervous system allows them to control certain leg muscles, when their legs have grown enough to support their weight, and when they want to move.

Mastering a motor skill requires the infant's active efforts to coordinate several components of the skill. Infants explore and select possible solutions to the demands of a new task; they assemble adaptive patterns by modifying their current movement patterns. The first step occurs when the infant is motivated by a new challenge—such as the desire to cross a

> The experiences of the first three years of life are almost entirely lost to us, and when we attempt to enter into a small child's world, we come as foreigners who have forgotten the landscape and no longer speak the native tongue.
>
> —Selma Fraiberg
>
> *Developmentalist and Child Advocate, 20th Century*

dynamic systems theory A theory proposed by Esther Thelen that seeks to explain how infants assemble motor skills for perceiving and acting.

How might dynamic systems theory explain the development of learning to walk?

developmental **connection**

Nature and Nurture

The epigenetic view states that development is an ongoing, bidirectional interchange between heredity and the environment. Chapter 2, pp. 62–63

rooting reflex A newborn's built-in reaction that occurs when the infant's cheek is stroked or the side of the mouth is touched. In response, the infant turns its head toward the side that was touched, in an apparent effort to find something to suck.

sucking reflex A newborn's reaction of sucking an object placed in its mouth. The sucking reflex enables the infant to get nourishment before it has begun to associate a nipple with food.

Moro reflex A startle response that occurs in reaction to a sudden, intense noise or movement. When startled, the newborn arches its back, throws its head back, and flings out its arms and legs. Then the newborn rapidly closes its arms and legs to the center of the body.

grasping reflex A reflex that occurs when something touches an infant's palms. The infant responds by grasping tightly.

gross motor skills Motor skills that involve large-muscle activities, such as walking.

room—and gets into the "ballpark" of the task demands by taking a couple of stumbling steps. Then, the infant "tunes" these movements to make them smoother and more effective. The tuning is achieved through repeated cycles of action and perception of the consequences of that action. According to the dynamic systems view, even universal milestones, such as crawling, reaching, and walking, are learned through this process of adaptation: Infants modulate their movement patterns to fit a new task by exploring and selecting possible configurations (Adolph & Robinson, 2013; Thelen & Smith, 2006).

To see how dynamic systems theory explains motor behavior, imagine that you offer a new toy to a baby named Gabriel (Thelen & others, 1993). There is no exact program that can tell Gabriel ahead of time how to move his arm and hand and fingers to grasp the toy. Gabriel must adapt to his goal—grasping the toy—and the context. From his sitting position, he must make split-second adjustments to extend his arm, holding his body steady so that his arm and torso don't plow into the toy. Muscles in his arm and shoulder contract and stretch in a host of combinations, exerting a variety of forces. He improvises a way to reach out with one arm and wrap his fingers around the toy.

Thus, according to dynamic systems theory, motor development is not a passive process in which genes dictate the unfolding of a sequence of skills over time. Rather, the infant actively puts together a skill to achieve a goal within the constraints set by the infant's body and environment. Nature and nurture, the infant and the environment, are all working together as part of an ever-changing system.

As you read about the course of motor development, you will see how dynamic systems theory applies to some specific skills. First, though, let's examine how the story of motor development begins with reflexes.

REFLEXES

The newborn is not completely helpless. Among other things, it has some basic reflexes. For example, the newborn holds its breath and contracts its throat to keep water out. Reflexes allow infants to respond adaptively to their environment before they have had the opportunity to learn.

The rooting and sucking reflexes are important examples. Both have survival value for newborn mammals, who must find a mother's breast to obtain nourishment. The **rooting reflex** occurs when the infant's cheek is stroked or the side of the mouth is touched. In response, the infant turns its head toward the side that was touched in an apparent effort to find something to suck. The **sucking reflex** occurs when newborns suck an object placed in their mouth. This reflex enables newborns to get nourishment before they have associated a nipple with food; it also serves as a self-soothing or self-regulating mechanism.

Another example is the **Moro reflex,** which occurs in response to a sudden, intense noise or movement (see Figure 5.1). When startled, the newborn arches its back, throws back its head, and flings out its arms and legs. Then the newborn rapidly closes its arms and legs. The Moro reflex is believed to be a way of grabbing for support while falling; it would have had survival value for our primate ancestors.

Some reflexes—coughing, sneezing, blinking, shivering, and yawning, for example—persist throughout life. They are as important for the adult as they are for the infant. Other reflexes, though, disappear several months following birth, as the infant's brain matures and voluntary control over many behaviors develops. The rooting and Moro reflexes, for example, tend to disappear when the infant is 3 to 4 months old.

The movements of some reflexes eventually become incorporated into more complex, voluntary actions. One important example is the **grasping reflex,** which occurs when something touches the infant's palms (see Figure 5.1). The infant responds by grasping tightly. By the end of the third month, the grasping reflex diminishes, and the infant shows a more voluntary grasp. As its motor development becomes smoother, the infant will grasp objects, carefully manipulate them, and explore their qualities.

Individual differences in reflexive behavior appear soon after birth. For example, the sucking capabilities of newborns vary considerably. Some newborns are efficient at sucking forcefully and obtaining milk; others are not as adept and get tired before they are full. Most infants take several weeks to establish a sucking style that is coordinated with the way the mother is holding the infant, the way milk is coming out of the bottle or breast, and the infant's temperament (Blass, 2008).

The old view of reflexes portrayed them as exclusively genetic, built-in mechanisms that govern the infant's movements. The new perspective on infant reflexes is that they are not automatic or completely beyond the infant's control. For example, infants can deliberately control such movements as alternating their legs to make a mobile jiggle or change their sucking rate to listen to a recording (Adolph & Berger, 2013).

Moro reflex

Grasping reflex

FIGURE **5.1**

NEWBORN REFLEXES

GROSS MOTOR SKILLS

Ask any parents about their baby, and sooner or later you are likely to hear about one or more advances in motor skills, such as "Cassandra just learned to crawl," "Jesse is finally sitting alone," or "Angela took her first step last week." Parents proudly announce such milestones as their children transform themselves from babies unable to lift their heads to toddlers who grab things off the grocery store shelf, chase a cat, and participate actively in the family's social life (Thelen, 2000). These milestones are examples of **gross motor skills,** skills that involve large-muscle activities such as moving one's arms and walking.

The Development of Posture How do gross motor skills develop? As a foundation, these skills require postural control (Adolph & Joh, 2009). For example, to track moving objects, you must be able to control your head in order to stabilize your gaze; before you can walk, you must be able to balance on one leg.

Posture is more than just holding still and straight. Posture is a dynamic process that is linked with sensory information in the skin, joints, and muscles, which tell us where we are in space; in vestibular organs in the inner ear that regulate balance and equilibrium; and in vision and hearing (Thelen & Smith, 2006).

Newborn infants cannot voluntarily control their posture. Within a few weeks, though, they can hold their heads erect, and soon they can lift their heads while prone. By 2 months of age, babies can sit while supported on a lap or an infant seat, but they cannot sit independently until they are 6 or 7 months of age. Standing also develops gradually during the first year of life. By about 8 to 9 months of age, infants usually learn to pull themselves up and hold onto a chair, and they often can stand alone by about 10 to 12 months of age.

Learning to Walk Locomotion and postural control are closely linked, especially in walking upright (Adolph & Berger, 2013; Adolph & Robinson, 2013). To walk upright, the baby must be able both to balance on one leg as the other is swung forward and to shift their weight from one leg to the other.

Even young infants can make the alternating leg movements that are needed for walking. The neural pathways that control leg alternation are in place from a very early age, even at birth or before. Indeed, researchers have found that alternating leg movements occur during the fetal period and at birth (Adolph & Robinson, 2013).

If infants can produce forward stepping movements so early, why does it take them so long to learn to walk? The key skills in learning to walk appear to be stabilizing balance on one leg long enough to swing the other forward and shifting the weight without falling. This is a difficult biomechanical problem to solve, and it takes infants about a year to do it.

In learning to locomote, infants discover what kinds of places and surfaces are safe for locomotion (Adolph & others, 2012). Karen Adolph (1997) investigated how experienced and inexperienced crawling infants and walking infants go down steep slopes (see Figure 5.2). Newly crawling infants, who averaged about 8½ months in age, rather indiscriminately went down the steep slopes, often falling in the process (with an experimenter next to the slope to catch them). After weeks of practice, the crawling babies became more adept at judging which slopes were too steep to crawl down and which ones they could navigate safely. New walkers also could not judge the safety of the slopes, but experienced walkers accurately matched their skills with the steepness of the slopes. They rarely fell downhill, either refusing to

What are some developmental changes in posture during infancy?

Newly crawling infant

Experienced walker

FIGURE **5.2**

THE ROLE OF EXPERIENCE IN CRAWLING AND WALKING INFANTS' JUDGMENTS OF WHETHER TO GO DOWN A SLOPE. *Source:* Karen Adolph (1997).

A baby is an angel whose wings decrease as his legs increase.

—French Proverb

go down the steep slopes or going down backward in a cautious manner. Experienced walkers perceptually assessed the situation—looking, swaying, touching, and thinking before they moved down the slope. With experience, both the crawlers and the walkers learned to avoid the risky slopes where they would fall, integrating perceptual information with the development of a new motor behavior. In this research, we again see the importance of perceptual-motor coupling in the development of motor skills. Thus, practice is very important in the development of new motor skills (Adolph & Berger, 2013; Adolph & Robinson, 2013). In a recent study, Adolph and her colleagues (2012) observed 12- to 19-month-olds during free play. Locomotor experience was extensive, with the infants averaging 2,368 steps and 17 falls per hour.

The First Year: Motor Development Milestones and Variations Figure 5.3 summarizes important accomplishments in gross motor skills during the first year, culminating in the ability to walk easily. The timing of these milestones, especially the later ones, may vary by as much as two to four months, and experiences can modify the onset of these accomplishments (Adolph & Berger, 2013). For example, in the early 1990s, pediatricians began recommending that parents place their babies on their backs when they sleep. Following that instruction, babies who back-sleep began crawling later, typically several weeks later than babies who slept prone (Davis & others, 1998). Also, some infants do not follow the standard sequence of motor accomplishments (Eaton, 2008). For example, many American infants never crawl on their belly or on their hands and knees. They may discover an idiosyncratic form of locomotion before walking, such as rolling, or they might never locomote until they get upright (Adolph & Robinson, 2013). In Jamaica, approximately one-fourth of babies skip crawling (Hopkins, 1991).

According to Karen Adolph and Sarah Berger (2005), the early view that growth and motor development simply reflect the age-related output of maturation is, at best, incomplete. Rather, infants develop new skills with the guidance of their caregivers in a real-world environment of objects, surfaces, and planes.

Development in the Second Year The motor accomplishments of the first year bring increasing independence, allowing infants to explore their environment more extensively and to initiate interaction with others more readily. In the second year of life, toddlers become more motorically skilled and mobile. Motor activity during the second year is vital to the child's competent development and few restrictions, except for safety, should be placed on their adventures.

By 13 to 18 months, toddlers can pull a toy attached to a string and use their hands and legs to climb up a number of steps. By 18 to 24 months, toddlers can walk quickly or run stiffly for a short distance, balance on their feet in a squatting position while playing with objects on the floor, walk backward without losing their balance, stand and kick a ball without falling, stand and throw a ball, and jump in place.

Can parents give their babies a head start on becoming physically fit and physically talented through structured exercise classes? Most infancy experts recommend against structured exercise classes for babies. But there are other ways to guide infants' motor development. Caregivers in some cultures do handle babies vigorously, and such treatment might advance motor development, as we discuss next.

Cultural Variations in Guiding Infants' Motor Development Mothers in developing countries tend to stimulate their infants' motor skills more than mothers in more developed countries (Hopkins, 1991). In many African, Indian, and Caribbean cultures, mothers massage and stretch their infants during daily baths (Adolph, Karasik, & Tamis-LeMonda, 2010). Mothers in the Gusii culture of Kenya also encourage vigorous movement in their babies.

Do these cultural variations make a difference in the infant's motor development? When caregivers provide babies with physical guidance by physically handling them in special ways (such as stroking, massaging, or stretching) or by giving them opportunities for exercise, the infants often reach motor milestones earlier than infants whose caregivers have not provided

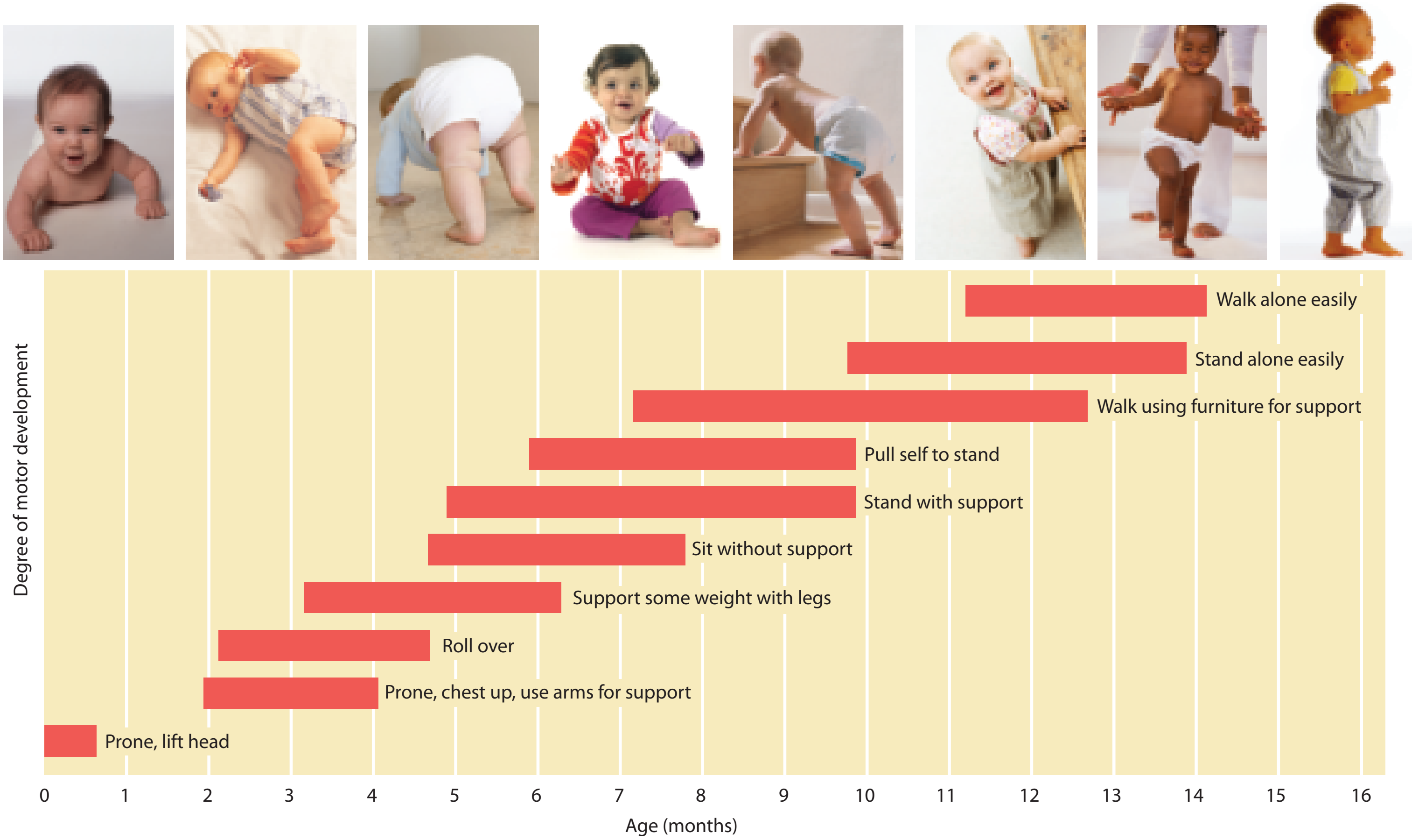
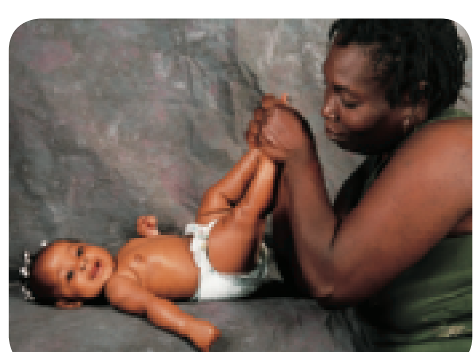


FIGURE **5.3**

MILESTONES IN GROSS MOTOR DEVELOPMENT. The horizontal red bars indicate the range in which most infants reach various milestones in gross motor development.

these activities (Adolph, Karasik, & Tamis-LeMonda, 2010). For example, Jamaican mothers expect their infants to sit and walk alone two to three months earlier than English mothers do (Hopkins & Westra, 1990). And in sub-Saharan Africa, traditional practices in many villages involve mothers and siblings engaging babies in exercises, such as frequent exercise for trunk and pelvic muscles (Super & Harkness, 2010).

Many forms of restricted movement—such as Chinese sandbags, orphanage restrictions, and failure of caregivers to encourage movement in Budapest—have been found to produce substantial delays in motor development (Adolph, Karasik, & Tamis-LeMonda, 2010). In some rural Chinese provinces, babies are placed in a bag of fine sand, which acts as a diaper and is changed once a day. The baby is left alone, face up, and is visited only when being fed by the



(*Left*) In the Algonquin culture in Quebec, Canada, babies are strapped to a cradle board for much of their infancy. (*Right*) In Jamaica, mothers massage and stretch their infants' arms and legs. *To what extent do cultural variations in the activity Infants engage In influence the time at which they reach motor milestones?*


What are some developmental changes in children's motor development in early childhood and middle and late childhood?

mother (Xie & Young, 1999). Some studies of swaddling show slight delays in motor development, but other studies show no delays. Cultures that swaddle infants usually do so before the infant is mobile. When the infant becomes more mobile, swaddling decreases.

Childhood The preschool child no longer has to make an effort to stay upright and to move around. As children move their legs with more confidence and carry themselves more purposefully, moving around in the environment becomes more automatic.

At 3 years of age, children enjoy simple movements, such as hopping, jumping, and running back and forth, just for the sheer delight of performing these activities. They take considerable pride in showing how they can run across a room and jump all of 6 inches. For the 3-year-old, such activity is a source of considerable pride in accomplishment.

At 4 years of age, children are still enjoying the same kind of activities, but they have become more adventurous. They scramble over low jungle gyms as they display their athletic prowess.

At 5 years of age, children are even more adventuresome than they were at 4. It is not unusual for self-assured 5-year-olds to perform hair-raising stunts on practically any climbing object. They run hard and enjoy races with each other and their parents.

During middle and late childhood, children's motor development becomes much smoother and more coordinated than it was in early childhood. For example, only one child in a thousand can hit a tennis ball over the net at the age of 3, yet by the age of 10 or 11 most children can learn to play the sport. Running, climbing, skipping rope, swimming, bicycle riding, and skating are just a few of the many physical skills elementary school children can master. And, when mastered, these physical skills are a source of great pleasure and a sense of accomplishment. In gross motor skills involving large-muscle activity, boys usually outperform girls.

Organized sports are one way of encouraging children to be active and to develop their motor skills. Schools and community agencies offer programs for children that involve baseball, soccer, football, basketball, swimming, gymnastics, and other sports. For children who participate in them, these programs may play a central role in their lives.

developmental **connection**

Health

Exercise is linked to prevention and effective treatment of many diseases. Chapter 4, pp. 149–150

Participation in sports can have both positive and negative consequences for children (Myer & others, 2011). Participation can provide exercise, opportunities to learn how to compete, self-esteem, persistence, and a setting for developing peer relations and friendships (Theokas, 2009). Further, participating in sports reduces the likelihood that children will become obese (Drake & others, 2012). A recent study revealed that 10- to 12-year-old girls who participated in extracurricular sports activities for more than 3 hours a week were 59 percent less likely to be overweight or obese than their nonparticipating counterparts (Antonogeorgos & others, 2011). However, sports also can bring pressure to achieve and win, physical injuries, a distraction from academic work, and unrealistic expectations for success as an athlete (Lerch, Cordes, & Baumeister, 2011; Pakzad-Vaezi & Singhal, 2012). The *Connecting Development to Life* interlude examines the roles of parents and coaches in children's sports.

Adolescence and Adulthood Gross motor skills typically improve during adolescence. Most of us reach our peak physical performance before the age of 30, often between the ages of 19 and 26. This peak occurs both for the average young adult and for outstanding athletes. Even though athletes keep getting better than their predecessors—running faster, jumping higher, and lifting more weight—the age at which they reach their peak performance has remained virtually the same (Schultz & Curnow, 1988). Most swimmers and gymnasts reach their peak in their late teens. Many athletes, including track performers in sprint races (100- and 200-yard dashes), peak in their early to mid-twenties. Golfers and marathon runners tend to peak in their late twenties or even early thirties.

connecting development to life

Parents, Coaches, and Children's Sports

Most sports psychologists stress that it is important for parents to show an interest in their children's sports participation. Most children want their parents to watch them perform in sports. Many children whose parents do not come to watch them play in sporting events feel that their parents do not adequately support them. However, some children become extremely nervous when their parents watch them perform, or they get embarrassed when their parents cheer too loudly or make a fuss. If children request that their parents not watch them perform, parents should respect their children's wishes (Schreiber, 1990).

Parents should praise their children for their sports performance, and if they don't become overinvolved, they can help their children build their physical skills and guide them emotionally by discussing with them how to deal with a difficult coach, how to cope with a tough loss, and how to put in perspective a poorly played game. The following guidelines provided by the Women's Sports Foundation (2001) in its booklet *Parents' Guide to Girls' Sports* can benefit both parents and coaches of all children in sports:

What are some of the possible positive and negative aspects of children's participation in sports?

The Dos

- Make sports fun; the more children enjoy sports, the more they will want to play.
- Remember that it is okay for children to make mistakes; it means they are trying.
- Allow children to ask questions about the sport and discuss the sport in a calm, supportive manner.
- Show respect for the child's sports participation.
- Be positive and convince the child that he or she is making a good effort.
- Be a positive role model for the child in sports.

The Don'ts

- Yell or scream at the child.
- Condemn the child for poor play or continue to bring up failures long after they happen.
- Point out the child's errors in front of others.
- Expect the child to learn something immediately.
- Expect the child to become a pro.
- Ridicule or make fun of the child.
- Compare the child to siblings or to more talented children.
- Make sports all work and no fun.

What developmental theories offer support for the Women's Sports Foundation's assertion that parents should strive to be positive role models for their children in sports?

After an individual reaches the age of 30, most biological functions begin to decline, although the decline of specific organs can vary considerably. The decline in general biological functioning that begins at about age 30 occurs at a rate of about 0.75 to 1 percent a year. Declines often occur in cardiovascular functioning, muscle strength, bone tissue (especially for females), neural function, balance, and flexibility.

Older adults move more slowly than young adults, and this slowing occurs for movements with a wide range of difficulty (Sakuma & Yamaguchi, 2010) (see Figure 5.4). Even when they perform everyday tasks such as reaching and grasping, moving from one place to another, and continuous movement, older adults tend to move more slowly than they did when they were young (Mollenkopf, 2007).

Recent research connects obesity with mobility limitation in older adults (Vincent, Raiser, & Vincent, 2012). Also, a recent study found that a combined program of physical activity and weight loss helped to preserve mobility in older, obese adults in poor cardiovascular health (Rejeski & others, 2011). And another study revealed that it's not just

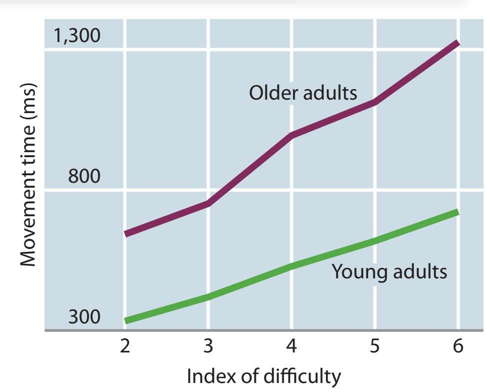


FIGURE 5.4

MOVEMENT AND AGING. Older adults take longer to move than young adults, and this change occurs across a range of movement difficulty (Ketcham & Stelmach, 2001).

connecting with older adults

Preventing Falls

What can older adults and their families do to help protect older adults from dangerous falls? A first step is understanding what causes elderly persons to fall (American Family Physician, 2000). Among the reasons are deteriorating eyesight or poor hearing, as well as illnesses and increasingly fragile bones and weaker muscle tone. Side effects of some medicines can cause elderly adults to become dizzy and lose their balance. Lack of physical activity can result in poor muscle tone, decreased bone mass, loss of balance, and less flexibility (Tremblay & Barber, 2005).

At least one-third of falls in the elderly are due to environmental hazards in the home. Poor lighting and throw rugs in their residence can cause them to trip and fall. Armed with this knowledge, older adults and their family members can make sure that the home environment is as fall-proof as possible.

Younger family members also can take an elderly adult on walks to see how stable their gait is and periodically observe the older adult's balance. If they observe that the elderly person is not getting adequate exercise, they can try to get him or her involved in an exercise program. By staying connected to elderly relatives, middle-aged and younger adults also can monitor whether the elderly person is getting regular medical checkups and whether any changes in medications might predispose the elderly person for falls.

Motor skills decline less in older adults who are active and biologically healthy. *What is the difference between chronological age and biological age?*

physical exercise and weight loss that are linked to preserving older adults' motor functions; in this study, engaging in social activities protected against loss of motor abilities (Buchman & others, 2009).

The risk of falling in older adults increases with age and is greater for women than for men. Two-thirds of older adults who experience a fall are likely to fall again in the next six months. Falls are the leading cause of injury deaths among adults who are 65 years and older (National Center for Health Statistics, 2010). Each year, approximately 200,000 adults over the age of 65 (many of them women) fracture a hip in a fall. Half of these older adults die within 12 months, frequently from pneumonia.

One study revealed that participation in an exercise class once a week for three years reduced the fall risk and the number of falling incidents in older adults who were at high risk for falling (Yokoya, Demura, & Sato, 2009). And a recent study indicated that a lower education level was linked to greater mobility disability in 70- to 79-year-old women (Gregory & others, 2011). To read further about preventing falls in older adults, see *Connecting with Older Adults.*

A young girl using a pincer grip to pick up puzzle pieces.

FINE MOTOR SKILLS

Whereas gross motor skills involve large-muscle activity, **fine motor skills** involve finely tuned movements. Buttoning a shirt, typing, or doing any task that requires finger dexterity demonstrates fine motor skills.

Infancy Infants have hardly any control over fine motor skills at birth, but newborns do have many components of what will become finely coordinated arm, hand, and finger movements. The onset of reaching and grasping marks a significant milestone in infants' increasing ability to interact with their surroundings (Greif & Needham, 2012; Ziemer, Plumert, & Pick, 2012). During the first two years of life, infants refine how they reach and grasp (Keen, 2011). Initially, infants reach by moving their shoulders and elbows crudely, swinging toward an object. Later, when infants reach for an object they move their wrists, rotate their hands, and coordinate their thumb and forefinger. Infants do not have to see their own hands in order to reach for an object (Clifton & others, 1993). Cues from muscles, tendons, and joints, not sight of the limb, guide reaching by 4-month-old infants.

Infants refine their ability to grasp objects by developing two types of grasps. Initially, infants grip with the whole hand, which is called the *palmer grasp*. Later, toward the end of the first year, infants also grasp small objects with their thumb and forefinger, which is called the *pincer grip*. Their grasping system is very flexible. They vary their grip on an object depending on its size, shape, and texture, as well as the size of their own hands relative to the object's size. Infants grip small objects with their thumb and forefinger (and sometimes their middle finger too), whereas they grip large objects with all of the fingers of one hand or both hands.

Perceptual-motor coupling is necessary for the infant to coordinate grasping (Keen, 2011). Which perceptual system the infant is most likely to use in coordinating grasping varies with age. Four-month-old infants rely greatly on touch to determine how they will grip an object; eight-month-olds are more likely to use vision as a guide (Newell & others, 1989). This developmental change is efficient because vision lets infants preshape their hands as they reach for an object.

FIGURE **5.5**
INFANTS' USE OF "STICKY MITTENS" TO EXPLORE OBJECTS. Amy Needham and her colleagues (2002) found that "sticky mittens" enhanced young infants' object exploration skills.

Experience plays a role in reaching and grasping. In one study, 3-month-old infants participated in play sessions wearing "sticky mittens"—"mittens with palms that stuck to the edges of toys and allowed the infants to pick up the toys" (Needham, Barrett, & Peterman, 2002, p. 279) (see Figure 5.5). Infants who participated in sessions with the mittens grasped and manipulated objects earlier in their development than a control group of infants who did not receive the "mitten" experience. The experienced infants looked at the objects longer, swatted at them more during visual contact, and were more likely to mouth the objects. In a recent study, 5-month-old infants whose parents trained them to use the sticky mittens for 10 minutes a day over a two-week period showed advances in their reaching behavior at the end of the two weeks (Libertus & Needham, 2010).

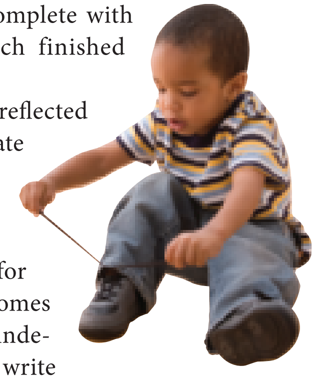
Just as infants need to exercise their gross motor skills, they also need to exercise their fine motor skills (Keen, 2011). Especially when they can manage a pincer grip, infants delight in picking up small objects. Many develop the pincer grip and begin to crawl at about the same time, and infants at this time pick up virtually everything in sight, especially on the floor, and put the objects in their mouth. Thus, parents need to be vigilant in regularly monitoring what objects are within the infant's reach (Keen, 2005).

Rachel Keen (2011) emphasizes that tool use is an excellent context for studying problem solving in infants because tool use provides information about how infants plan to reach a goal. Researchers in this area have studied infants' intentional actions that range from picking up a spoon in different orientations to retrieving rakes placed inside tubes. A recent study explored motor origins of tool use by assessing developmental changes in banging movements in 6- to 15-month-olds (Kahrs, Jung, & Lockman, 2013). In this study, younger infants were inefficient and variable when banging an object but by one year of age infants showed consistent straight up-and-down hand movements that resulted in precise aiming and consistent levels of force.

Childhood and Adolescence As children get older, their fine motor skills improve (Sveistrup & others, 2008). At 3 years of age, children have had the ability to pick up the tiniest objects between their thumb and forefinger for some time, but they are still somewhat clumsy at it. Three-year-olds can build surprisingly high block towers, each block placed with intense concentration but often not in a completely straight line. When 3-year-olds play with a form board or a simple puzzle, they are rather rough in placing the pieces. Even when they recognize the hole that a piece fits into, they are not very precise in positioning the piece. They often try to force the piece in the hole or pat it vigorously.

By 4 years of age, children's fine motor coordination has become much more precise. Sometimes 4-year-old children have trouble building high towers with blocks because, in their desire to place each of the blocks perfectly, they may upset those already stacked. By age 5, children's fine motor coordination has improved further. Hand, arm, and fingers all move together under better command of the eye. Mere towers no longer interest the

fine motor skills Motor skills that involve finely tuned movements, such as any activity that requires finger dexterity.



5-year-old, who now wants to build a house or a church, complete with steeple, though adults may still need to be told what each finished project is meant to be.

Increased myelination of the central nervous system is reflected in the improvement of fine motor skills during middle and late childhood. Children use their hands more adroitly as tools. Six-year-olds can hammer, paste, tie shoes, and fasten clothes. By 7 years of age, children's hands have become steadier. At this age, children prefer a pencil to a crayon for printing, and reversal of letters is less common. Printing becomes smaller. At 8 to 10 years of age, children can use their hands independently with more ease and precision; children can now write rather than print words. Letter size becomes smaller and more even. At 10 to 12 years of age, children begin to show manipulative skills similar to the abilities of adults. The complex, intricate, and rapid movements needed to produce fine-quality crafts or to play a difficult piece on a musical instrument can be mastered. Girls usually outperform boys in fine motor skills.

Adult Development Fine motor skills may undergo some decline in middle and late adulthood as dexterity decreases, although for most healthy individuals, fine motor skills, such as reaching and grasping, continue to be performed in functional ways. However, pathological conditions may result in weakness or paralysis of an individual's hands, in which case performance of fine motor skills may be impossible.

Review *Connect* Reflect

LG1 Describe how motor skills develop

Review

- What is the dynamic systems view of motor development?
- What are reflexes? What are some reflexes of infants?
- What are gross motor skills, and how do they develop?
- What are fine motor skills? How do fine motor skills develop?

Connect

- How does the development of infants' gross motor skills differ from the development of fine motor skills?

Reflect *Your Own Personal Journey of Life*

- Imagine that you are the parent of a 7-year-old child. How would you evaluate the benefits and drawbacks of allowing him or her to participate in organized competitive sports such as soccer, basketball, or tennis?

Sensory and Perceptual Development

LG2 Outline the course of sensory and perceptual development

- What Are Sensation and Perception?
- The Ecological View
- Visual Perception
- Hearing
- Other Senses
- Intermodal Perception
- Nature/Nurture and Perceptual Development

How do sensations and perceptions develop? Can a newborn see? If so, what can it perceive? What about the other senses—hearing, smell, taste, touch, and pain? What are they like in the newborn, and how do they develop? How do sensation and perception change when adults become older? These are among the intriguing questions that we explore in this section.

WHAT ARE SENSATION AND PERCEPTION?

How does a newborn know that her mother's skin is soft rather than rough? How does a 5-year-old know what color his hair is? How does a 10-year-old know that a firecracker is louder than a cat's meow? Infants and children "know" these things because of information that comes through the senses. Without vision, hearing, touch, taste, smell, and other senses, we would be isolated from the world; we would live in dark silence, a tasteless, colorless, feelingless void.

Sensation occurs when information interacts with sensory *receptors*—the eyes, ears, tongue, nostrils, and skin. The sensation of hearing occurs when waves of pulsating air are collected by the outer ear and conducted through the bones of the inner ear and the *cochlea*, where mechanical vibrations are converted into electrical impulses. Then the electrical impulses move to the *auditory nerve*, which transmits them to the brain. The sensation of vision occurs as rays of light contact the eyes and become focused on the *retina*, where light is converted into electrical impulses. Then the electrical impulses are transmitted by the *optic nerve* to the visual centers of the brain.

Perception is the interpretation of what is sensed. The air waves that contact the ears might be interpreted as noise or as musical sounds, for example. The physical energy transmitted to the retina of the eye might be interpreted as a particular color, pattern, or shape, depending on how it is perceived.

THE ECOLOGICAL VIEW

In recent decades, much of the research on perceptual development in infancy has been guided by the ecological view of Eleanor and James J. Gibson (E. Gibson, 1969, 1989, 2001; J. Gibson, 1966, 1979). They argue that we do not have to take bits and pieces of data from sensations and build up representations of the world in our minds. Instead, our perceptual system can select from the rich information that the environment itself provides.

According to the Gibsons' **ecological view,** we directly perceive information that exists in the world around us. Perception brings us into contact with the environment in order to interact with and adapt to it. Perception is designed for action. Perception gives people such information as when to duck, when to turn their bodies to get through a narrow passageway, and when to put up their hands to catch something.

How would you use the Gibsons' ecological theory of perception and the concept of affordance to explain the role that perception is playing in this baby's activity?

In the Gibsons' view, all objects and surfaces have **affordances,** which are opportunities for interaction offered by objects that fit within our capabilities to perform activities. A pot may afford you something to cook with, and it may afford a toddler something to bang. Adults immediately know when a chair is appropriate for sitting, when a surface is safe for walking, or when an object is within reach. We directly and accurately perceive these affordances by sensing information from the environment—the light or sound reflecting from the surfaces of the world—and from our own bodies through muscle receptors, joint receptors, and skin receptors (Ziemer, Plumert, & Pick, 2012).

An important developmental question is "What affordances can infants or children detect and use?" In one study, for example, when babies who could walk were faced with a squishy waterbed, they stopped and explored it, then chose to crawl rather than walk across it (Gibson & others, 1987). They combined perception and action to adapt to the demands of the task.

Studying the infant's perception has not been an easy task. What do you think some of the research challenges might be? The *Connecting with Research* interlude describes some of the ingenious ways researchers study the infant's perception.

sensation Reaction that occurs when information interacts with sensory receptors—the eyes, ears, tongue, nostrils, and skin.

perception The interpretation of sensation.

ecological view The view proposed by the Gibsons that people directly perceive information in the world around them. Perception brings people in contact with the environment in order to interact with it and adapt to it.

affordances Opportunities for interaction offered by objects that fit within our capabilities to perform activities.

connecting with research

How Do Scientists Study the Newborn's Perception?

Scientists have developed a number of research methods and tools sophisticated enough to examine the subtle abilities of infants and to interpret their complex actions (Bendersky & Sullivan, 2007).

Visual Preference Method

Robert Fantz (1963) was a pioneer in this effort. Fantz made an important discovery that advanced the ability of researchers to investigate infants' visual perception: Infants look at different things for different lengths of time. Fantz placed infants in a "looking chamber," which had two visual displays on the ceiling above the infant's head. An experimenter viewed the infant's eyes by looking through a peephole. If the infant was fixating on one of the displays, the experimenter could see the display's reflection in the infant's eyes. This arrangement allowed the experimenter to determine how long the infant looked at each display. Fantz (1963) found that infants only 2 days old look longer at patterned stimuli, such as faces and concentric circles, than at red, white, or yellow discs. Infants 2 to 3 weeks old preferred to look at patterns—a face, a piece of printed matter, or a bull's-eye—longer than at red, yellow, or white discs (see Figure 5.6). Fantz's research method—studying whether infants can distinguish one stimulus from another by measuring the length of time they attend to different stimuli—is referred to as the **visual preference method.**

Habituation and Dishabituation

Another way that researchers have studied infant perception is to present a stimulus (such as a sight or a sound) a number of times. If the infant decreases its response to the stimulus after several presentations, this change indicates that the infant is no longer interested in looking at the stimulus. If the researcher now presents a new stimulus, the infant's response will recover—an indication that the infant can discriminate between the old and new stimulus (Snyder & Torrence, 2008).

Habituation is the name given to decreased responsiveness to a stimulus after repeated presentations of the stimulus. **Dishabituation** is the recovery of a habituated response after a change in stimulation. Newborn infants can habituate to repeated sights, sounds, smells, or touches (Rovee-Collier, 2004). Among the measures researchers use in habituation studies are sucking behavior (sucking stops when the young infant attends to a novel object), heart and respiration rates, and the length of time the infant looks at an object. Figure 5.7 shows the results of one study of habituation and dishabituation with newborns (Slater, Morison, & Somers, 1988).

High-Amplitude Sucking

To assess an infant's attention to sound, researchers often use a method called *high-amplitude sucking.* In this assessment method, infants are given a nonnutritive nipple to suck, and the nipple is connected to a sound-generating system. The researcher computes a baseline high-amplitude sucking rate in a one-minute silent period. Following the baseline, presentation of a sound is made contingent on the rate of high-amplitude sucking. Initially babies suck frequently so the sound occurs often. Gradually, they lose interest in hearing the

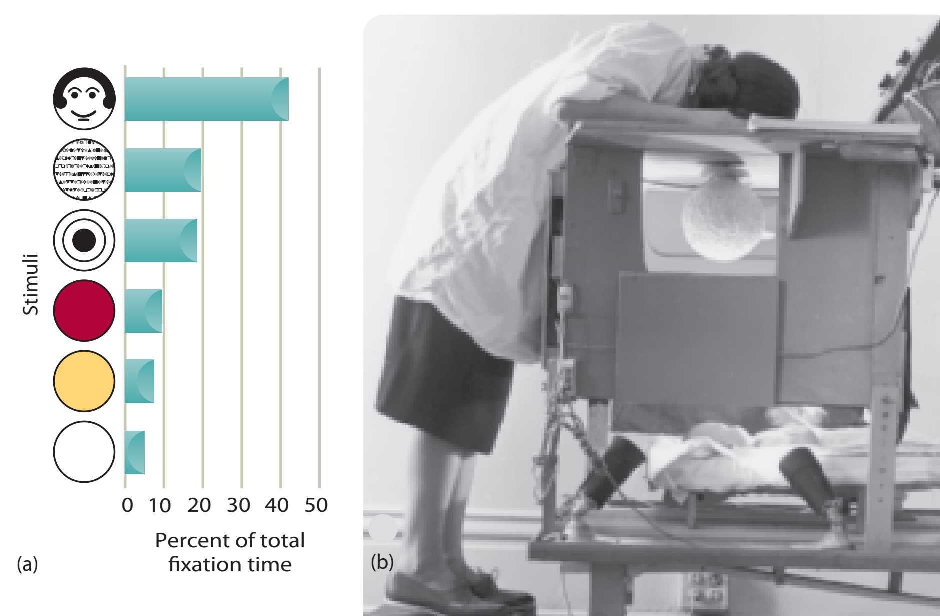


FIGURE **5.6**
FANTZ'S EXPERIMENT ON INFANTS' VISUAL PERCEPTION. (*a*) Infants 2 to 3 weeks old preferred to look at some stimuli more than others. In Fantz's experiment, infants preferred to look at patterns rather than at color or brightness. For example, they looked longer at a face, a piece of printed matter, or a bull's-eye than at red, yellow, or white discs. (*b*) Fantz used a "looking chamber" to study infants' perception of stimuli.

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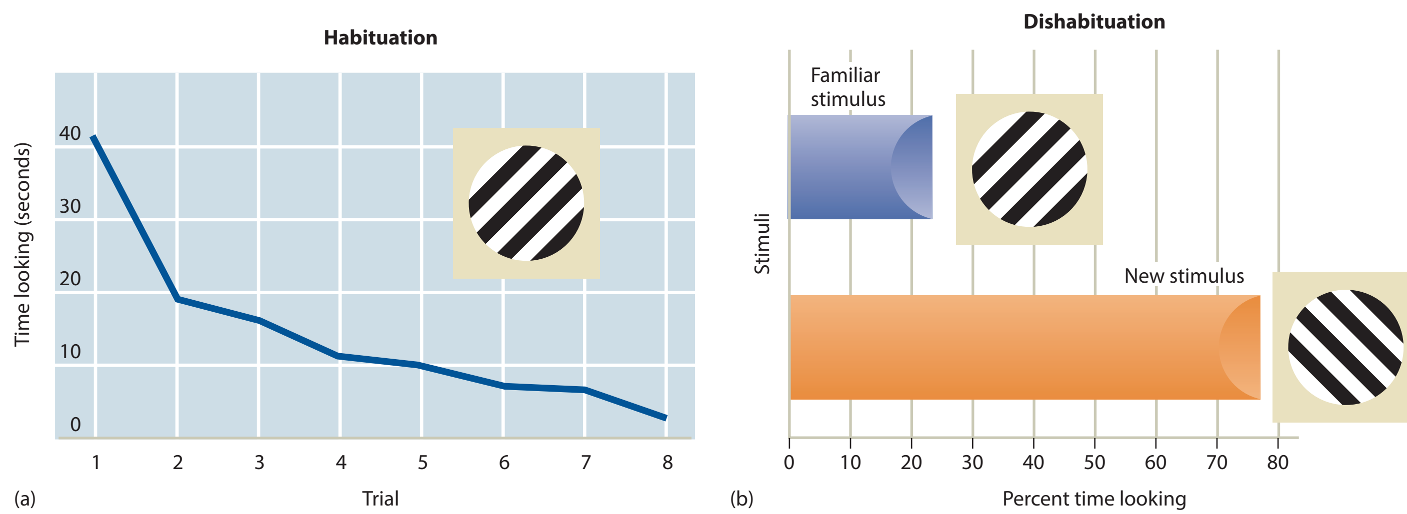

FIGURE **5.7**

HABITUATION AND DISHABITUATION. In the first part of one study (*a*), 7-hour-old newborns were shown a stimulus. As indicated, the newborns looked at it an average of 41 seconds when it was first presented to them (Slater, Morison, & Somers, 1988). Over seven more presentations of the stimulus, they looked at it less and less. In the second part of the study (*b*), infants were presented with both the familiar stimulus to which they had just become habituated and a new stimulus (which was rotated 90 degrees). The newborns looked at the new stimulus three times as much as the familiar stimulus.

same sound so they begin to suck less often. Then the researcher changes the sound that is being presented. If the babies renew their vigorous sucking, the inference is that they have discriminated the sound change and are sucking more because they want to hear the interesting new sound (Menn & Stoel-Gammon, 2009).

The Orienting Response

A technique that can be used to determine whether an infant can see or hear is the *orienting response,* which involves turning one's head toward a sight or sound. Another technique, *tracking,* measures eye movements that follow (track) a moving object; it can be used to evaluate an infant's early visual ability. A startle response can be used to determine an infant's reaction to a noise (Bendersky & Sullivan, 2007).

Equipment

Technology can facilitate the use of most methods for investigating the infant's perceptual abilities. Videotape equipment allows researchers to investigate elusive behaviors.

FIGURE **5.8**

AN INFANT WEARING EYE-TRACKING HEADGEAR. Using the ultralight, wireless, head-mounted eye-tracking equipment shown here, researchers can record where infants look while the infants freely locomote. (*Source:* Courtesy of Dr. Karen Adolph's laboratory, New York University.)

High-speed computers make it possible to perform complex data analysis in minutes. Other equipment records respiration, heart rate, body movement, visual fixation, and sucking behavior, which provide clues to what the infant is perceiving.

The most important recent advance in measuring infant perception is the development of sophisticated eye-tracking equipment (Bulf & Valenza, 2013; Eisner & others, 2013; Franchak & others, 2011; Morgante, Zolfaghari, & Johnson, 2012; Navab & others, 2012). Figure 5.8 shows an infant wearing an eye-tracking headgear in a recent study on visually guided motor behavior and social interaction.

One of the main reasons that infant perception researchers are so enthusiastic about the recent availability of sophisticated eye-tracking equipment is that looking time is among the most important measures of infant perceptual and cognitive development (Aslin, 2012). The new

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eye-tracking equipment allows for much greater precision than human observation in assessing various aspects of infant looking and gaze (Oakes, 2012). Among the areas of infant perception in which eye-tracking equipment is being used are memory, joint attention, and face processing (Falck-Yttere & others, 2012; Wheeler & others, 2011). Further, eye-tracking equipment is improving our understanding of atypically developing infants, such as those with autism (Sasson & Elison, 2012), and infants at risk for atypical developmental outcomes, including infants at risk for developing autism and preterm infants (Bedford & others, 2012).

A recent eye-tracking study shed light on the effectiveness of TV programs and DVDs that claim to educate infants (Kirkorian, Anderson, & Keen, 2012). In this study, 1-year-olds, 4-year-olds, and adults watched *Sesame Street* and the eye-tracking equipment recorded precisely what they looked at on the screen. The 1-year-olds were far less likely to consistently look at the same part of the screen as their older counterparts, suggesting that the 1-year-olds showed little understanding of the *Sesame Street* video but instead were more likely to be attracted by what was salient than by what was relevant.

Scientists have become ingenious at assessing the development of infants, discovering ways to "interview" them even though they cannot yet talk. How might researchers account for any individual differences in infant development in their studies?

VISUAL PERCEPTION

Some important changes in visual perception as we age can be traced to differences in how the eye itself functions over time. These changes in the eye's functioning influence, for example, how clearly we can see an object, whether we can differentiate its colors, at what distances, and in what light. But the differences between what the newborn sees and what a toddler or an adult sees go far beyond those that can be explained by changes in the eye's functioning, as we discuss in this section.

Infancy

Psychologist William James (1890/1950) called the newborn's perceptual world a "blooming, buzzing confusion." More than a century later, we can safely say that he was wrong (Johnson, 2012, 2013). Even the newborn perceives a world with some order. That world, however, is far different from the one perceived by the toddler or the adult.

Visual Acuity

Just how well can infants see? At birth, the nerves and muscles and lens of the eye are still developing. As a result, newborns cannot see small things that are far away. The newborn's vision is estimated to be 20/240 on the well-known Snellen chart used for eye examinations, which means that a newborn can see at 20 feet what a normal adult can see at 240 feet (Aslin & Lathrop, 2008). In other words, an object 20 feet away is only as clear to the newborn as it would be if it were 240 feet away from an adult with normal vision (20/20). By 6 months of age, though, average visual acuity is 20/40 (Aslin & Lathrop, 2008).

Infants show an interest in human faces soon after birth (Lee & others, 2013). Figure 5.9 shows a computer estimation of what a picture of a face looks like to an infant at different ages from a distance of about 6 inches. Infants spend more time looking at their mother's face than a stranger's face as early as 12 hours after being born (Bushnell, 2003). By 3 months of age, infants match voices to faces, distinguish between male and female faces, and discriminate between faces of their own ethnic group and those of other ethnic groups (Gaither & others, 2012; Kelly & others, 2007, 2009; Liu & others, 2011).

Also, as we discussed in the *Connecting with Research* interlude, young infants can perceive certain patterns. With the help of his "looking chamber," Robert Fantz (1963) revealed that even 2- to 3-week-old infants prefer to look at patterned displays rather than nonpatterned displays. For example, they prefer to look at a normal human face rather than one with scrambled features, and prefer to look at a bull's-eye target or black and white stripes rather than a plain circle.

visual preference method A method developed by Fantz to determine whether infants can distinguish one stimulus from another by measuring the length of time they attend to different stimuli.

habituation Decreased responsiveness to a stimulus after repeated presentations of the stimulus.

dishabituation The recovery of a habituated response after a change in stimulation.

FIGURE **5.9**

VISUAL ACUITY DURING THE FIRST MONTHS OF LIFE. The four photographs represent a computer estimation of what a picture of a face looks like to a 1-month-old, 2-month-old, 3-month-old, and 1-year-old (whose visual acuity approximates that of an adult).

Color Vision The infant's color vision also improves over time (Aslin & Lathrop, 2008; Atkinson & Braddick, 2013). By 8 weeks, and possibly by even 4 weeks, infants can discriminate some colors (Kelly, Borchert, & Teller, 1997). By 4 months of age, they have color preferences that mirror those of adults in some cases, preferring saturated colors such as royal blue over pale blue, for example (Bornstein, 1975). A recent study of the reactions to blue, yellow, red, and green hues by 4- to 5-month-old infants revealed that they looked longest at reddish hues and shortest at greenish hues (Franklin & others, 2010). In part, the changes in vision described here reflect maturation. Experience, however, is also necessary for color vision to develop normally (Sugita, 2004).

Perceptual Constancy Some perceptual accomplishments are especially intriguing because they indicate that the infant's perception goes beyond the information provided by the senses (Johnson, 2012, 2013; Slater & others, 2011). This is the case in perceptual constancy, in which sensory stimulation is changing but perception of the physical world remains constant. If infants did not develop perceptual constancy, each time they saw an object at a different distance or in a different orientation, they would perceive it as a different object. Thus, the development of perceptual constancy allows infants to perceive their world as stable. Two types of perceptual constancy are size constancy and shape constancy.

Size constancy is the recognition that an object remains the same even though the retinal image of the object changes as you move toward or away from the object. The farther away from us an object is, the smaller its image is on our eyes. Thus, the size of an object on the retina is not sufficient to tell us its actual size. For example, you perceive a bicycle standing right in front of you as smaller than the car parked across the street, even though the bicycle casts a larger image on your eyes than the car does. When you move away from the bicycle, you do not perceive it to be shrinking even though its image on your retinas shrinks; you perceive its size as constant. But what about babies? Do they have size constancy? Researchers have found that babies as young as 3 months of age show size constancy (Bower, 1966; Day & McKenzie, 1973). However, at 3 months of age, a baby's ability is not full-blown. It continues to develop until 10 or 11 years of age (Kellman & Banks, 1998).

Shape constancy is the recognition that an object remains the same shape even though its orientation to us changes. Look around the room you are in right now. You likely see objects of varying shapes, such as tables and chairs. If you get up and walk around the room, you will see these objects from different sides and angles. Even though your retinal image of the objects changes as you walk and look, you will still perceive the objects as the same shape.

Do babies have shape constancy? As with size constancy, researchers have found that babies as young as 3 months of age have shape constancy (Bower, 1966; Day & McKenzie, 1973). Three-month-old infants, however, do not have shape constancy for irregularly shaped objects such as tilted planes (Cook & Birch, 1984).

Perception of Occluded Objects Look around the context where you are now. You likely see that some objects are partly occluded by other objects that are in front of them—possibly a desk behind a chair, some books behind a computer, or a car parked behind a tree. Do infants perceive an object as complete when it is partly occluded by an object in front of it?

size constancy Recognition that an object remains the same even though the retinal image of the object changes as the viewer moves toward or away from the object.

shape constancy Recognition that an object remains the same even though its orientation to the viewer changes.

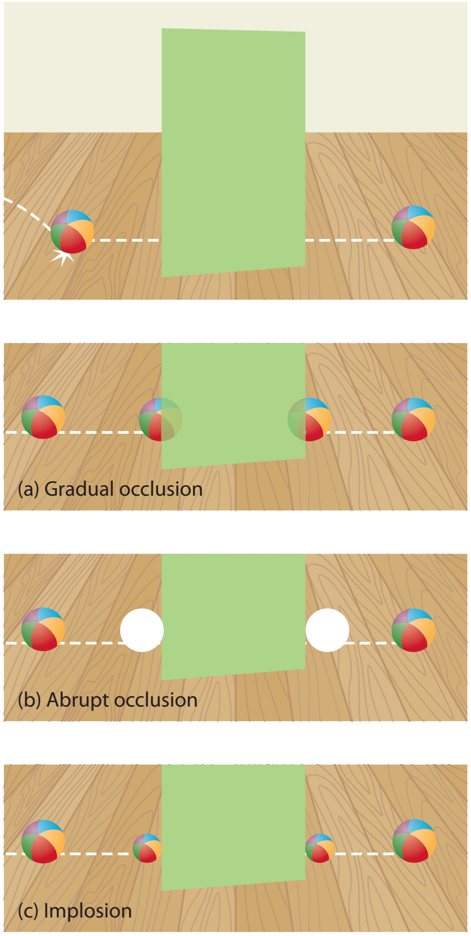


FIGURE **5.10**

INFANTS' PREDICTIVE TRACKING OF A BRIEFLY OCCLUDED MOVING BALL

In the first two months of postnatal development, infants don't perceive occluded objects as complete, but instead perceive only what is visible (Johnson, 2012, 2013). Beginning at about 2 months of age, infants develop the ability to perceive that occluded objects are whole (Slater & others, 2010). How does perceptual completion develop? In Scott Johnson's (2004, 2009, 2010, 2011, 2012, 2013) research, learning, experience, and self-directed exploration via eye movements play key roles in the development of perceptual completion in young infants.

Many of the objects in the world that are occluded appear and disappear behind closer objects, as when you are walking down the street and see cars appear and disappear behind buildings as they move or you move. Can infants predictively track briefly occluded moving objects? They develop the ability to track briefly occluded moving objects at about 3 to 5 months of age (Bertenthal, 2008). One study explored 5- to 9-month-old infants' ability to track moving objects that disappeared gradually behind an occluded partition, disappeared abruptly, or imploded (shrank quickly in size) (see Figure 5.10) (Bertenthal, Longo, & Kenny, 2007). In this study, the infants were more likely to accurately predict the reappearance of the moving object when it disappeared gradually rather than disappearing abruptly or imploding.

Depth Perception Might infants even perceive depth? To investigate this question, Eleanor Gibson and Richard Walk (1960) constructed a miniature cliff with a drop-off covered by glass in their laboratory. They placed infants on the edge of this visual cliff and had their mothers coax them to crawl onto the glass (see Figure 5.11). Most infants would not crawl out on the glass, choosing instead to remain on the shallow side, an indication that they could perceive depth. However, critics point out that the visual cliff likely is a better test of social referencing and fear of heights than of depth perception.

The 6- to 12-month-old infants in the visual cliff experiment had extensive visual experience. Do younger infants without this experience still perceive depth? Since younger infants do not crawl, this question is difficult to answer. Two- to four-month-old infants show differences in heart rate when they are placed directly on the deep side of the visual cliff instead of on the shallow side (Campos, Langer, & Krowitz, 1970). However, these differences might mean that young infants respond to differences in some visual characteristics of the deep and shallow cliffs, with no actual knowledge of depth (Adolph & Kretch, 2012). Although researchers do not know exactly how early in life infants can perceive depth, we do know that infants develop the ability to use binocular cues to depth by about 3 to 4 months of age.

FIGURE **5.11**

EXAMINING INFANTS' DEPTH PERCEPTION ON THE VISUAL CLIFF. Eleanor Gibson and Richard Walk (1960) found that most infants would not crawl out on the glass, which, according to Gibson and Walk, indicated that they had depth perception. However, critics suggest that the visual cliff may be a better indication of the infant's social referencing and fear of heights than of the infant's perception of depth.

Childhood Changes in children's perceptual development continue in childhood (Atkinson & Braddick, 2013; Lee & others, 2013). Children become increasingly efficient at detecting the boundaries between colors (such as red and orange) at 3 to 4 years of age (Gibson, 1969). When children are about 4 or 5 years old, their eye muscles usually are developed enough that they can move their eyes efficiently across a series of letters. Many preschool children are farsighted, unable to see close up as well as they can see far away. By the time they enter the first grade, though, most children can focus their eyes and sustain their attention effectively on close-up objects.

What are the signs of vision problems in children? They include rubbing the eyes, blinking or squinting excessively, appearing irritable when playing games that require good distance vision, shutting or covering one eye, and tilting the head or thrusting it forward when looking at something. A child who shows any of these behaviors should be examined by an ophthalmologist.

After infancy, children's visual expectations about the physical world continue to develop. In one study, 2- to 4½-year-old children were given a task in which the goal was to find a ball that had been dropped through an opaque tube (Hood, 1995). As shown in Figure 5.12, if the ball is dropped into the tube at the top right, it will land in the box at the bottom left. However, in this task, most of the 2-year-olds, and even some of the 4-year-olds, persisted in searching in the box immediately beneath the dropping point. For them, gravity ruled and they had failed to perceive the end location of the curved tube.

In a recent study 3-year-olds were presented with the same task shown in Figure 5.12 (Joh, Jaswal, & Keen, 2011). In the group that was told to imagine the various paths the ball might take, the young children were more accurate in predicting where the ball would land. In another recent study, 3-year-olds improved their performance on the ball-dropping task shown in Figure 5.12 when they were instructed to follow the tube with their eyes to the bottom (Bascandziev & Harris, 2011). Thus, in these two studies, 3-year-olds were able to overcome the gravity bias and their impulsive tendencies when they were given verbal instructions from a knowledgeable adult (Keen, 2011).

How do children learn to deal with situations like that in Figure 5.12, and how do they come to understand other laws of the physical world? These questions are addressed by studies of cognitive development, which we discuss in Chapter 6, "Cognitive Developmental Approaches," and Chapter 7, "Information Processing."

FIGURE **5.12**

VISUAL EXPECTATIONS ABOUT THE PHYSICAL WORLD. When young children see the ball dropped into the tube, many of them will search for it immediately below the dropping point.

Adulthood Vision changes little after childhood until the effects of aging emerge (Hochberg & others, 2012). With aging, declines in visual acuity, color vision, and depth perception occur. Several diseases of the eye also may emerge in aging adults.

Visual Acuity **Accommodation of the eye**—the eye's ability to focus and maintain an image on the retina—declines most sharply between 40 and 59 years of age. This loss of accommodation is what is commonly known as *presbyopia*. In particular, middle-aged individuals begin to have difficulty viewing close objects. The eye's blood supply also diminishes, although usually not until the fifties or sixties. The reduced blood supply may decrease the visual field's size and account for an increase in the eye's *blind spot*, the location where the retina does not register any light. And there is some evidence that the retina becomes less sensitive to low levels of illumination (Hughes, 1978). As a result, middle-aged adults begin to have difficulty reading or working in dim light. Presbyopia is correctable with bifocals, reading glasses, laser surgery, or implantation of intraocular lenses. Indeed, laser surgery and implantation of intraocular lenses have become routine procedures for correcting vision in middle-aged adults (Ang, Evans, & Mehta, 2012; Pasquali & Krueger, 2012).

developmental **connection**

Information Processing

Perceptual speed declines in middle adulthood and late adulthood. Chapter 7, p. 223

In late adulthood, the decline in vision that began for most adults in early or middle adulthood becomes more pronounced (Polat & others, 2012). Visual processing speed declines in older adults (Owsley, 2011). Night driving is especially difficult, to some extent because of diminishing sensitivity to contrasts and reduced tolerance for glare (van Rijn & others, 2011). *Dark adaptation* is slower—that is, older individuals take longer to recover their vision when going from a well-lighted room to semidarkness. The area of the visual field becomes smaller, an indication that the intensity of a stimulus in the peripheral area of the visual field needs to be increased if the stimulus is to be seen. Events taking place away from the center of the visual field might not be detected (West & others, 2010).

This visual decline often can be traced to a reduction in the quality or intensity of light reaching the retina. At 60 years of age, the retina receives only about one-third as much light as it did at 20 years of age (Scialfa & Kline, 2007). In extreme old age, these changes might be accompanied by degenerative changes in the retina, causing severe difficulty in seeing. Large-print books and magnifiers might be needed in such cases.

One extensive study of visual changes in adults found that the age of older adults was a significant factor in how extensively their visual functioning differed from that of younger adults (Brabyn & others, 2001). Beyond 75, and more so beyond age 85, older adults showed significantly worse performance on a number of visual tasks in comparison with young adults and people in their sixties and early seventies. The greatest decline in visual perception beyond age 75, and especially beyond age 85, involved glare. The older adults, especially those 85 and older, fared much worse in being able to see clearly when glare was present, and they took much longer to recover from glare than did younger

accommodation of the eye The eye's ability to focus and maintain an image on the retina.

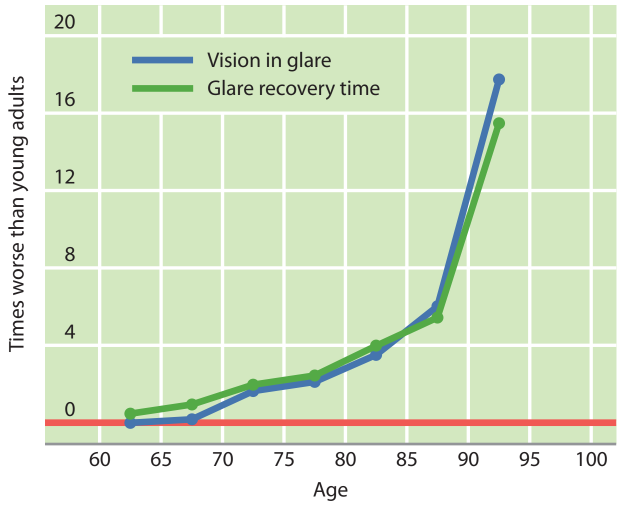


FIGURE **5.13**

RATES OF DECLINE IN VISUAL FUNCTIONING RELATED TO GLARE IN ADULTS OF DIFFERENT AGES. Older adults, especially those 85 and older, fare much worse than younger adults in being able to see clearly when glare is present, and their recovery time from glare is much slower. These data were collected from a random sample of community-dwelling older adults living in Marin County, California. For each age, the factor by which the group's median performance was worse than normative values for young adults is shown.

adults (see Figure 5.13). For example, whereas young adults recover vision following glare in less than 10 seconds, 50 percent of 90-year-olds have not recovered vision after 1.5 minutes.

Older adults also show a decline in motion sensitivity (Henderson & others, 2010; Mateus & others, 2013). In terms of practical applications of this decline, researchers have found that compared with younger drivers, older drivers underestimate the time needed for an approaching vehicle to reach their location (Staplin, Lococo, & Sim, 1993). This decline in the accuracy of effortless perceptual guidance means that older adult drivers need to expend cognitive effort when driving, especially when approaching intersections.

What are some concerns about older adults' driving based on changes in visual perception?

Research has shown that sensory decline in older adults is linked to a decline in cognitive functioning. One study of individuals in their seventies revealed that visual decline was related to slower speed of processing information, which in turn was associated with greater cognitive decline (Clay & others, 2009).

Color Vision Color vision also may decline with age in older adults as a result of the yellowing of the lens of the eye (Scialfa & Kline, 2007). This decline is most likely to occur in the green-blue-violet part of the color spectrum. As a result, older adults may have trouble accurately matching closely related colors such as navy socks and black socks.

FIGURE **5.14**

MACULAR DEGENERATION. This simulation of the effect of macular degeneration shows how individuals with this eye disease can see their peripheral field of vision but can't clearly see what is in their central visual field.

Depth Perception As with many areas of perception, depth perception changes little after infancy until adults become older. Depth perception typically declines in late adulthood, which can make it difficult for the older adult to determine how close or far away or how high or low something is (Bian & Andersen, 2008). A decline in depth perception can make steps or street curbs difficult to manage.

Diseases of the Eye Three diseases that can impair the vision of older adults are cataracts, glaucoma, and macular degeneration:

- **Cataracts** are a thickening of the lens of the eye that causes vision to become cloudy, opaque, and distorted (Choi & others, 2012; Huang & others, 2013). By age 70, approximately 30 percent of individuals experience a partial loss of vision due to cataracts. Initially, cataracts can be treated by glasses; if they worsen, a simple surgical procedure can remove the cloudy lens and replace it with an artificial one (Chung & others, 2009). Diabetes is a risk factor for the development of cataracts (Olafsdottir, Andersson, & Stefansson, 2012).
- **Glaucoma** damages the optic nerve because of the pressure created by a buildup of fluid in the eye (Kokotas & others, 2012). Approximately 1 percent of individuals in their seventies and 10 percent of those in their nineties have glaucoma, which can be treated with eye drops. If left untreated, glaucoma can ultimately destroy a person's vision.
- **Macular degeneration** is a disease that causes deterioration of the macula of the retina, which corresponds to the focal center of the visual field (see Figure 5.14). Individuals with macular degeneration may have relatively normal peripheral vision but be unable to see clearly what is right in front of them (Miller, 2013; Taylor, 2012). Macular degeneration affects 1 in 25 individuals from 66 to 74 years of age and 1 in 6 of those 75 years old and older. If the disease is detected early, it can be treated with laser surgery (Sorensen & Kemp, 2010). However, macular degeneration is difficult to treat and thus a leading cause of blindness in older adults (Lucifero, 2010). A recent study found that macular degeneration was linked to increased risk of falls in adults 77 years and older (Wood & others, 2011).

cataracts A thickening of the lens of the eye that causes vision to become cloudy, opaque, and distorted.

glaucoma Damage to the optic nerve because of pressure created by a buildup of fluid in the eye.

macular degeneration A vision problem in the elderly that involves deterioration of the macula of the retina.

(a)

(b)

FIGURE **5.15**

HEARING IN THE WOMB. (*a*) Pregnant mothers read *The Cat in the Hat* to their fetuses during the last few months of pregnancy. (*b*) When they were born, the babies preferred listening to a recording of their mothers reading *The Cat in the Hat,* as evidenced by their sucking on a nipple that produced this recording, rather than another story, *The King, the Mice and the Cheese.*

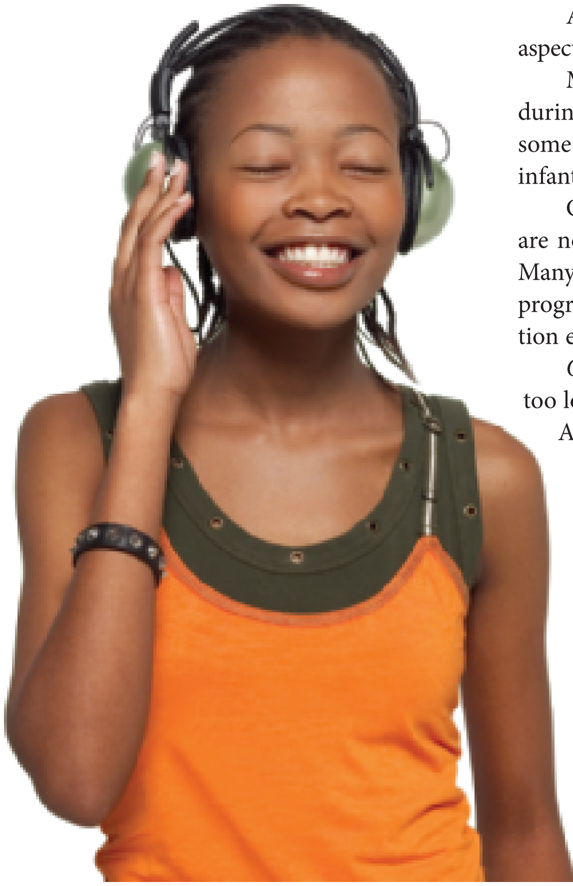
HEARING

Can the fetus hear? What kind of changes in hearing take place in infancy? When does hearing begin to decline in adulthood?

The Fetus, Infant, and Child During the last two months of pregnancy, as the fetus nestles in its mother's womb, it can hear sounds such as the mother's voice, music, and so on (Kisilevsky & others, 2009; Morokuma & others, 2008). Two psychologists wanted to find out whether a fetus who heard Dr. Seuss' classic story *The Cat in the Hat* while still in the mother's womb would prefer hearing the story after birth (DeCasper & Spence, 1986). During the last months of pregnancy, 16 women read *The Cat in the Hat* to their fetuses. Then, shortly after the infants were born, the mothers read aloud either *The Cat in the Hat* or a story with a different rhyme and pace, *The King, the Mice and the Cheese* (which they had not read aloud during prenatal development). The infants sucked on a nipple in a different way when the mothers read the two stories, suggesting that they recognized the pattern and tone of *The Cat in the Hat* (see Figure 5.15). This study illustrates not only that a fetus can hear but also that it has a remarkable ability to learn even before birth. A recent fMRI study confirmed that the fetus can hear at 33 to 34 weeks into the prenatal period by assessing fetal brain response to auditory stimuli (Jardri & others, 2012).

Hearing in Infancy What kind of changes in hearing take place during infancy? They involve perception of a sound's loudness, pitch, and localization:

- *Loudness*. Immediately after birth, infants cannot hear soft sounds quite as well as adults can; a stimulus must be louder to be heard by a newborn than by an adult (Trehub & others, 1991). For example, an adult can hear a whisper from about 4 to 5 feet away, but a newborn requires that sounds be closer to a normal conversational level to be heard at that distance. By three months of age, infants' perception of sounds improves, although some aspects of loudness perception do not reach adult levels until 5 to 10 years of age (Trainor & He, 2013).
- *Pitch*. Infants are also less sensitive to the pitch of a sound than adults are. Pitch is the perception of the frequency of a sound. A soprano voice sounds high-pitched, a bass voice low-pitched. Infants are less sensitive to low-pitched sounds and are more likely to hear high-pitched sounds (Aslin, Jusczyk, & Pisoni, 1998). By 2 years of age, infants have considerably improved their ability to distinguish sounds with different pitches. A recent study revealed that by 7 months of age, infants can process simultaneous pitches when they hear voices but they are more likely to encode the higher-pitched voice (Marie & Trainor, 2012).
- *Localization*. Even newborns can determine the general location from which a sound is coming, but by 6 months of age they are more proficient at localizing sounds (detecting their origins). Their ability to localize sounds continues to improve during the second year (Burnham & Mattock, 2010).



What are some concerns about adolescents who listen to loud music?

Although young infants can process variations in sound loudness, pitch, and localization, these aspects of hearing continue to improve through the childhood years (Trainor & He, 2013).

Most children's hearing is adequate, but early hearing screening tests should be conducted during infancy (Russ & others, 2010). About 1 in 1,000 newborns is deaf and 6 in 1,000 have some degree of hearing loss. Hearing aids or surgery can improve hearing for many of these infants (Halpin & others, 2010).

Cochlear implants—small, electronic devices that directly stimulate the auditory nerve—are now provided routinely to congenitally deaf children, even as early as 12 months of age. Many of the hearing-impaired children who have early cochlear implant surgery show good progress in learning speech and in understanding others' speech, which allows them to function effectively in a hearing world (Asp, Eskilsson, & Berninger, 2011; Peixoto & others, 2013).

Otitis media is a middle-ear infection that can impair hearing temporarily. If it continues too long, it can interfere with language development and socialization (Casey & others, 2011). As many as one-third of all U.S. children from birth to 3 years of age have three or more episodes of otitis media. In some cases, the infection can develop into a more chronic condition in which the middle ear becomes filled with fluid, which can seriously impair hearing. Treatments for otitis media include antibiotics and placement of a tube in the inner ear to drain fluid (Daniel, 2013; Wald, 2011).

Adolescence Most adolescents' hearing is excellent. However, anyone who listens to loud sounds for sustained periods of time is at risk for hearing problems. H.E.A.R. (Hearing Education and Awareness for Rockers) was founded by rock musicians whose hearing has been damaged by exposure to high-volume rock music. Increasingly, rock groups wear earplugs when they are playing loud music. Listening to loud music on iPods and MP3 players also can produce hearing problems.

Adulthood and Aging Few changes in hearing are believed to take place during the adult years until middle adulthood (Feeney & Sanford, 2004). Hearing can start to decline by the age of 40. Sensitivity to high pitches usually declines first. The ability to hear low-pitched sounds does not seem to decline much in middle adulthood, however. Men usually lose their sensitivity to high-pitched sounds sooner than women do, but this sex difference might be due to men's greater exposure to noise in occupations such as mining and automobile work.

Hearing impairment usually does not become much of an impediment until late adulthood (Pacala & Yeuh, 2012). Only 19 percent of individuals from 45 to 54 years of age experience some type of hearing problem (Harris, 1975). A recent national survey revealed that 63 percent of adults age 70 years and older had a hearing loss defined as an inability to hear sounds softer than 25 dB with their better ear (Lin & others, 2011). In this study, hearing aids were used by 40 percent of those with moderate hearing loss (inability to hear sounds softer than 40 dB with their better ear). Fifteen percent of the population over the age of 65 is estimated to be legally deaf, usually due to degeneration of the cochlea, the primary neural receptor for hearing in the inner ear (Adams, 2009). A recent study found that hearing loss was associated with a reduction in cognitive functioning in older adults (Lin, 2011). Another recent study revealed that the perceptual difficulties associated with hearing loss affect language comprehension and memory for spoken language in older adults (Tun & others, 2012). And a recent study across 10 years also found that poor nutrition and a lifetime of smoking were linked to more rapid hearing difficulties over time in older adults (Heine & others, 2013).

Two devices can be used to minimize problems created by hearing loss: (1) hearing aids that amplify sound to reduce middle-ear-based conductive hearing loss, and (2) cochlear implants that restore some hearing following neurosensory hearing loss (Di Nardo & others, 2013; Kidd & Bao, 2012). Currently, researchers are exploring the use of stem cells as an alternative to cochlear implants (Parker, 2011).

Earlier, in discussing changes in vision, we considered research on the importance of the age of older adults in determining the degree of their visual decline. Age also is a factor in the degree of hearing decline in older adults (Li-Korotky, 2012). As indicated in Figure 5.16, the declines in vision and hearing are much greater in individuals 75 years and older than in individuals 65 to 74 years of age (Charness & Bosman, 1992).

Perceptual System	Young-Old (65 to 74 years)	Old-Old (75 years and older)
Vision	There is a loss of acuity even with corrective lenses. Less transmission of light occurs through the retina (half as much as in young adults). Greater susceptibility to glare occurs. Color discrimination ability decreases.	There is a significant loss of visual acuity and color discrimination, and a decrease in the size of the perceived visual field. In late old age, people are at significant risk for visual dysfunction from cataracts and glaucoma.
Hearing	There is a significant loss of hearing at high frequencies and some loss at middle frequencies. These losses can be helped by a hearing aid. There is greater susceptibility to masking of what is heard by noise.	There is a significant loss at high and middle frequencies. A hearing aid is more likely to be needed than in young-old age.

FIGURE **5.16**

VISION AND HEARING DECLINE IN THE YOUNG-OLD AND THE OLD-OLD

Older adults often don't recognize that they have a hearing problem, deny that they have one, or accept it as a part of growing old (Pacala & Yeuh, 2012). A recent study found that severe age-related hearing loss was linked to impaired ability to perform activities of daily living (Gopinath & others, 2012).

Vision impairment and hearing loss among older adults can significantly influence their health and functioning. One study found that 20 percent of individuals 70 years and older had both visual and hearing impairment, and the dual impairment was associated with greater difficulty in performing daily activities, such as preparing meals, shopping, and using a telephone (Brennan, Horowitz, & Su, 2005). Another study revealed that individuals 70 years and older with only hearing loss reported that they were less healthy, engaged in fewer activities, and participated less in social roles than their counterparts without sensory loss (Crews & Campbell, 2004). In this study, older adults with only vision loss showed even more impairment in health and functioning than those with only hearing loss, and those with both vision and hearing loss had the greatest declines in health and functioning. Hearing loss in older adults is also linked to increased depression (Levy, Slade, & Gill, 2006).

OTHER SENSES

As we develop, we not only obtain information about the world from our eyes and our ears but also through sensory receptors in our skin, nose, and tongue.

Touch and Pain Do newborns respond to touch (called tactile stimulation)? Can they feel pain? How does the perception of touch and pain change with age?

Infancy Newborns do respond to touch. A touch to the cheek produces a turning of the head; a touch to the lips produces sucking movements.

Newborns can also feel pain (Gunnar & Quevado, 2007). If and when you have a son and consider whether he should be circumcised, the issue of an infant's pain perception probably will become important to you. When circumcision is performed during infancy, it usually takes place between the third and eighth days after birth. Will your young son experience pain if he is circumcised when he is 3 days old? An investigation by Megan Gunnar and her colleagues (1987) found that infant males cried intensely during circumcision. The circumcised infants also displayed amazing resiliency. Within several minutes after the surgery, they could nurse and interact in a normal manner with their mothers. And, if allowed to, the newly circumcised infants drifted into a deep sleep, which seemed to serve as a coping mechanism.

For many years, doctors performed operations on newborns without administering anesthesia. This practice was accepted because of the dangers of anesthesia and because of the supposition that newborns do not feel pain. When researchers discovered that newborns feel pain, the practice of operating on newborns without anesthesia began to be reconsidered. Anesthesia is now used in some circumcisions as well as other surgical procedures performed during infancy (Morris & others, 2012).

Adulthood There has been little research on developmental changes in touch and pain after infancy until the middle and late adulthood years. Changes in touch and pain are associated with aging (Lenz & others, 2012). One study found that older adults could detect

FIGURE **5.17**

NEWBORNS' PREFERENCE FOR THE SMELL OF THEIR MOTHER'S BREAST PAD. In the experiment by MacFarlane (1975), 6-day-old infants preferred to smell their mother's breast pad rather than a clean one that had never been used, but 2-day-old infants did not show the preference, indicating that this odor preference requires several days of experience to develop.

touch much less in the lower extremities (ankles, knees, and so on) than in the upper extremities (wrists, shoulders, and so on) (Corso, 1977). For most older adults, though, a decline in touch sensitivity is not problematic (Hoyer & Roodin, 2009).

Older adults are less sensitive to pain and suffer from it less than younger adults do (Gagliese, 2009). Although decreased sensitivity to pain can help older adults cope with disease and injury, it can be harmful if it masks injury or illness that needs to be treated.

Smell Newborns can differentiate odors (Doty & Shah, 2008). The expressions on their faces seem to indicate that they like the way vanilla and strawberry smell but do not like the way rotten eggs and fish smell (Steiner, 1979). In one investigation, 6-day-old infants who were breast fed showed a clear preference for smelling their mother's breast pad rather than a clean breast pad (MacFarlane, 1975) (see Figure 5.17). However, when they were 2 days old, they did not show this preference, an indication that they require several days of experience to recognize this odor.

A decline in sensitivity to odors may occur as early as the twenties, with declines continuing through each subsequent decade of life into the nineties (Margran & Boulton, 2005). Beginning in the sixties, the decrease in sensitivity to smells becomes more noticeable to most people (Hawkes, 2006). A majority of individuals 80 years of age and older experience a significant reduction in smell (Lafreniere & Mann, 2009). A decline in the sense of smell can reduce the ability to detect smoke from a fire.

The decline in the olfactory system can reduce older adults' enjoyment of food and their life satisfaction. If elderly individuals need to be encouraged to eat more, compounds that stimulate the olfactory nerve are sometimes added to food.

Taste Sensitivity to taste is present even before birth (Doty & Shah, 2008). Human newborns learn tastes prenatally through the amniotic fluid and in breast milk after birth (Beauchamp & Mennella, 2009; Mennella, 2009). In one study, even at only 2 hours of age, babies made different facial expressions when they tasted sweet, sour, and bitter solutions (Rosenstein & Oster, 1988) (see Figure 5.18). At about 4 months of age, infants begin to prefer salty tastes, which as newborns they had found to be aversive (Doty & Shah, 2008).

One study found a significant reduction in the ability of older adults to recognize sweet, salty, sour, and bitter tastes (Fukunaga, Uematsu, & Sugimoto, 2005). As with smell, there is less decline in taste in healthy older adults than in unhealthy older adults. However, when even relatively healthy older adults take medications, their taste sensitivity declines (Roberts & Rosenberg, 2006). Many older adults prefer highly seasoned foods (sweeter, spicier, saltier) to compensate for their diminished taste and smell (Hoyer & Roodin, 2009). This preference can lead to increased eating of nonnutritious, highly seasoned "junk food."

Researchers have found that older adults show a greater decline in their sense of smell than in their taste (Schiffman, 2007). Smell, too, declines less in healthy older adults than in their less healthy counterparts.

(a) (b) (c)

FIGURE **5.18**

NEWBORNS' FACIAL RESPONSES TO BASIC TASTES. Facial expressions elicited by (*a*) a sweet solution, (*b*) a sour solution, and (*c*) a bitter solution.

INTERMODAL PERCEPTION

Imagine that you are playing basketball or tennis. You are experiencing many visual inputs—the ball is coming and going, other players are moving around, and so on. However, you are experiencing many auditory inputs as well: the sound of the ball bouncing or being hit, the grunts and groans of the other players, and so on. There is good correspondence between much of the visual and auditory information: When you see the ball bounce, you hear a bouncing sound; when a player stretches to hit a ball, you hear a groan. When you look at and listen to what is going on, you do not experience just the sounds or just the sights; you put all of these things together. You experience a unitary episode. This is **intermodal perception,** which involves integrating information from two or more sensory modalities, such as vision and hearing (Bremner & others, 2012). Most perception is intermodal (Bahrick, 2010; Kirkham & others, 2012).

Early, exploratory forms of intermodal perception exist even in newborns (Bahrick & Hollich, 2008). For example, newborns turn their eyes and their head toward the sound of a voice or rattle when the sound is maintained for several seconds (Clifton & others, 1981), but the newborn can localize a sound and look at an object only in a crude way (Bechtold, Bushnell, & Salapatek, 1979). These early forms of intermodal perception become sharpened with experience in the first year of life (Kirkham & others, 2012). In one study, infants as young as 3½ months old looked more at their mother when they also heard her voice and longer at their father when they also heard his voice (Spelke & Owsley, 1979). Thus, even young infants can coordinate visual-auditory information about people.

How is intermodal perception involved in this context in which a boy is listening to headphones while working on a computer?

Can young infants put vision and sound together as precisely as adults do? In the first six months, infants have difficulty connecting sensory input from different modes, but in the second half of the first year they show an increased ability to make this connection mentally.

NATURE/NURTURE AND PERCEPTUAL DEVELOPMENT

Now that we have discussed many aspects of perceptual development, let's explore one of developmental psychology's key issues as it relates to perceptual development: the nature-nurture issue. There has been a long-standing interest in how strongly infants' perception is influenced by nature or nurture (Johnson, 2011, 2012, 2013; Slater & others, 2011). In the field of perceptual development, nature proponents are referred to as *nativists* and those who emphasize learning and experience are called *empiricists*.

In the nativist view, the ability to perceive the world in a competent, organized way is inborn or innate. At the beginning of our discussion of perceptual development, we examined the ecological view of the Gibsons because it has played such a pivotal role in guiding research in perceptual development. In some quarters, the Gibsons' ecological view has been described as leaning toward a nativist explanation of perceptual development because it holds that perception is direct and evolved over time to allow the detection of size and shape constancy, a three-dimensional world, intermodal perception, and so on early in infancy. However, the Gibsons' view is not entirely nativist because they emphasized that perceptual development involves distinctive features that are detected at different ages (Slater & others, 2011). Further, the Gibsons argued that a key question in infant perception is what information is available in the environment and how infants learn to generate, differentiate, and discriminate the information—certainly not a nativist view.

What roles do nature and nurture play in the infant's perceptual development?

The Gibsons' ecological view is quite different from Piaget's constructivist view (discussed in Chapter 1), which reflects an empiricist approach to explaining perceptual development. According to Piaget, much of perceptual development in infancy must await the development of a sequence of cognitive stages for infants to construct more complex perceptual tasks. Thus, in Piaget's view, the ability to perceive size and shape constancy, a three-dimensional world, intermodal perception, and so on develops later in infancy than the Gibsons envision.

The longitudinal research of Daphne Maurer and her colleagues (Lewis & Maurer, 2009; Maurer & Lewis, 2013; Maurer & others, 1999) has focused on infants born with cataracts—a thickening of the lens of the eye that causes vision to become cloudy, opaque, and distorted and thus severely restricts infants' ability to experience their visual world. Studying infants whose

intermodal perception The ability to integrate information about two or more sensory modalities, such as vision and hearing.

developmental connection

Theories

Piaget's theory states that children construct their understanding of the world through four stages of cognitive development. Chapter 1, p. 23; Chapter 6, p. 192

cataracts were removed at different points in development, they discovered that those whose cataracts were removed and new lenses placed in their eyes in the first several months after birth showed a normal pattern of visual development. However, the longer the delay in removing the cataracts, the more their visual development was impaired. In their research, Maurer and her colleagues (2007) have found that experiencing patterned visual input early in infancy is important for holistic and detailed face processing after infancy. Maurer's research program illustrates how deprivation and experience influence visual development, particularly during an early sensitive period in which visual input is necessary for normal visual development (Maurer & Lewis, 2013).

Today, it is clear that an extreme empiricist position on perceptual development is unwarranted. Much of early perception develops from innate (nature) foundations, and the basic foundation of many perceptual abilities can be detected in newborns, whereas others unfold maturationally (Arterberry, 2008). However, as infants develop, environmental experiences (nurture) refine or calibrate many perceptual functions, and they may be the driving force behind some functions. The accumulation of experience with and knowledge about their perceptual world contributes to infants' ability to perceive coherent impressions of people and things (Johnson, 2011, 2012, 2013; Slater & others, 2011). Thus, a full portrait of perceptual development includes the influence of nature, nurture, and a developing sensitivity to information (Arterberry, 2008).

Review *Connect* Reflect

LG2 Outline the course of sensory and perceptual development

Review

- What are sensation and perception?
- What is the ecological view of perception? What are some research methods used to study infant perception?
- How does vision develop?
- How does hearing develop?
- How do sensitivity to touch and pain develop? How does smell develop? How does taste develop?
- What is intermodal perception, and how does it develop?
- What roles do nature and nurture play in perceptual development?

Connect

- How might the development of vision and hearing contribute to infants' gross motor development?

Reflect *Your Own Personal Journey of Life*

- Imagine that you are the parent of a 1-year-old infant. How would you stimulate your 1-year-old's vision and hearing?

Perceptual-Motor Coupling

LG3 Discuss the connection between perception and action

As we come to the end of this chapter, we return to the important theme of perceptual-motor coupling. The distinction between perceiving and doing has been a time-honored tradition in psychology. However, a number of experts on perceptual and motor development question whether this distinction makes sense (Adolph & Berger, 2013; Thelen & Smith, 2006). The main thrust of research in Esther Thelen's dynamic systems approach is to explore how people assemble motor behaviors for perceiving and acting. The main theme of the ecological approach of Eleanor and James J. Gibson is to discover how perception guides action. Action can guide perception, and perception can guide action. Only by moving one's eyes, head, hands, and arms and by moving from one location to another can an individual fully experience his or her environment and learn how to adapt to it. Perception and action are coupled.

Babies, for example, continually coordinate their movements with perceptual information to learn how to maintain balance, reach for objects in space, and move across various surfaces and terrains (Adolph & Robinson, 2013; Thelen & Smith, 2006). They are motivated to move by what they perceive. Consider the sight of an attractive toy across the room. In this situation, infants must perceive the current state of their bodies and learn how to use their limbs to reach the toy. Although their movements at first are awkward and uncoordinated, babies soon learn to select patterns that are appropriate for reaching their goals.


Perception and action are coupled throughout the human life span.

Equally important is the other part of the perception-action coupling. That is, action educates perception (Adolph & Robinson, 2013). For example, watching an object while exploring it manually helps infants to discriminate its texture, size, and hardness. Locomoting in the environment teaches babies about how objects and people look from different perspectives, or whether surfaces will support their weight. Individuals perceive in order to move and move in order to perceive. Perceptual and motor development do not occur in isolation from each other but instead are coupled.

How do infants develop new perceptual-motor couplings? Recall from our discussion earlier in this chapter that in the traditional view of Gesell, infants' perceptual-motor development is prescribed by a genetic plan to follow a fixed and sequential progression of stages in development. The genetic determination view has been replaced by the dynamic systems view that infants learn new perceptual-motor couplings by assembling skills for perceiving and acting. New perceptual-motor coupling is not passively accomplished; rather, the infant actively develops a skill to achieve a goal within the constraints set by the infant's body and the environment (Adolph & Berger, 2013).

The infant is by no means as helpless as it looks and is quite capable of some very complex and important actions.

—Herb Pick

Contemporary developmental psychologist, University of Minnesota

Driving a car illustrates the coupling of perceptual and motor skills. The decline in perceptual-motor skills in late adulthood makes driving a car difficult for many older adults (Dawson & others, 2010; Stavrinos & others, 2013). Drivers over the age of 65 are involved in more traffic accidents than middle-aged adults because of mistakes such as improper turns, not yielding the right of way, and not obeying traffic signs; their younger counterparts are more likely to have accidents because they are speeding (Sterns, Barrett, & Alexander, 1985; Lavalliere & others, 2011). Older adults can compensate for declines in perceptual-motor skills by driving shorter distances, choosing less congested routes, and driving only in daylight.

A recent extensive research review evaluated the effectiveness of two types of interventions in improving older adults' driving: cognitive training and education (Ross, Schmidt, & Ball, 2012):

- *Cognitive training.* Cognitive training programs have shown some success in older adults, including improving their driving safety and making driving less difficult. In one study conducted by Karlene Ball and her colleagues (2010), training designed to enhance speed of processing produced more than a 40 percent reduction in at-fault crashes over a six-year period.
- *Education.* Results are mixed with regard to educational interventions that seek to improve older adults' driving ability and reduction in accidents (Gaines & others, 2011).

Review Connect Reflect

LG3 Discuss the connection between perception and action

Review

- How are perception and action coupled in development?

Connect

- If perception and action are closely linked, can parents enhance their infants' motor development or must it follow its own course?

Reflect *Your Own Personal Journey of Life*

- Describe two examples not given in the text in which perception guides action. Then describe two examples not given in the text in which action guides perception.

reach your **learning goals**

Motor, Sensory, and Perceptual Development

Motor Development

LG1 Describe how motor skills develop

The Dynamic Systems View

- Thelen's dynamic systems theory seeks to explain how motor behaviors are assembled by infants for perceiving and acting. Perception and action are coupled. According to this theory, motor skills are the result of many converging factors, such as the development of the nervous system, the body's physical properties and its movement possibilities, the goal the child is motivated to reach, and environmental support for the skill. In the dynamic systems view, motor development involves far greater complexity than the unfolding of a genetic blueprint.

Reflexes

- Reflexes govern the newborn's movements. They include the sucking, rooting, and Moro reflexes.

Gross Motor Skills

- Gross motor skills involve large-muscle activities. Key skills developed during infancy include control of posture and walking. Gross motor skills improve dramatically during childhood. Peak levels of physical performance often occur between 19 and 26 years of age. In general, older adults show a slowing of movement.

Fine Motor Skills

- Fine motor skills involve finely tuned motor actions. The onset of reaching and grasping marks a significant accomplishment. Fine motor skills continue to develop during childhood and then decline somewhat with aging. Neural noise and strategy have been proposed as possible explanations for the slowing of motor behavior in older adults.

Sensory and Perceptual Development

LG2 Outline the course of sensory and perceptual development

What Are Sensation and Perception?

- Sensation occurs when information interacts with sensory receptors. Perception is the interpretation of sensation.

The Ecological View

- Created by the Gibsons, the ecological view states that people directly perceive information that exists in the world. Perception brings people in contact with the environment so that they can interact with and adapt to it. Affordances provide opportunities for interaction offered by objects that fit within our capabilities to perform activities. Researchers have developed a number of methods to assess the infant's perception, including the visual preference method (which Fantz used to determine young infants' interest in looking at patterned over nonpatterned displays), habituation and dishabituation, and tracking.

Visual Perception

- The infant's visual acuity increases dramatically during the first year of life. Infants can distinguish some colors by 8 weeks of age and possibly by as early as 4 weeks. Young infants systematically scan human faces. By 3 months of age, infants show size and shape constancy. As visual perception develops, infants develop visual expectations. In Gibson and Walk's classic study, infants as young as 6 months of age had depth perception. Much of vision develops from biological foundations, but environmental experiences can contribute to the development of visual perception. During the preschool years, children become better at differentiating colors and scanning the visual world. After the early adult years, visual acuity declines. Eye accommodation decreases the most from 40 to 59 years of age. In older adults, the yellowing of the eye's lens reduces color differentiation, and the ability to see the periphery of a visual field declines. Significant declines in visual functioning related to glare characterize adults 75 years and older and are even more severe among those who are 85 years and older. Three diseases that can impair the vision of older adults are cataracts, glaucoma, and macular degeneration.

Hearing

- The fetus can hear sounds such as the mother's voice and music during the last two months of pregnancy. Immediately after birth newborns can hear, but their sensory threshold is higher than that of adults. Developmental changes in the perception of loudness, pitch, and localization of sound occur during infancy. Most children's hearing is adequate, but one special concern is otitis media. Hearing can start to decline by the age of 40, especially sensitivity to high-pitched sounds. However, hearing impairment usually doesn't become much of an impediment until late adulthood. Hearing aids can diminish hearing problems for many older adults.

Other Senses

- Newborns can respond to touch and feel pain. Sensitivity to pain decreases in late adulthood. Newborns can differentiate odors, and sensitivity to taste is present before birth. Smell and taste may decline in late adulthood, although in healthy individuals the decline is minimal.

Intermodal Perception

- Crude, exploratory forms of intermodal perception—the ability to relate and integrate information from two or more sensory modalities—are present in newborns and become sharpened over the first year of life.

Nature/Nurture and Perceptual Development

- In perception, nature advocates are referred to as nativists and nurture proponents are called empiricists. The Gibsons' ecological view that has guided much of perceptual development research leans toward a nativist approach but still allows for developmental changes in distinctive features. Piaget's constructivist view leans toward an empiricist approach, emphasizing that many perceptual accomplishments must await the development of cognitive stages in infancy. A strong empiricist approach is unwarranted. A full account of perceptual development acknowledges the roles of nature, nurture, and the developing sensitivity to information.

Perceptual-Motor Coupling

LG3 Discuss the connection between perception and action

- Perception and action often are not isolated but rather are coupled. Action can guide perception and perception can guide action. Individuals perceive in order to move and move in order to perceive.

key terms

dynamic systems theory 159
rooting reflex 160
sucking reflex 160
Moro reflex 160
grasping reflex 160
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fine motor skills 167
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Chapter 5 | MOTOR, SENSORY, AND PERCEPTUAL DEVELOPMENT

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Learning Objectives	Application Activities	Activity Type	Page Reference
Describe how motor skills develop.	MilestonesL Bi-Pedal Posture and Dynamic Systems Theory, Colin, 2 wks–14 mos	Milestones	pp. 160–162
	Milestones: Infant Reflexes, Amalia, 2 wks–7 mos	Milestones	
	Milestones: Gross Motor Skills, Colin, 2–14 wks	Milestones	
	Milestones: Gross Motor Skills, Amalia, 2–28 wks	Milestones	
	Milestones: Gross Motor Control, Kestrel, 5–12 mos	Milestones	
	Milestones: Gross Motor Control, Del, 6–12 mos	Milestones	
	Milestones: Locomotion, Esme, 10–16 mos	Milestones	
	Milestones: Gross Motor Control, Amalia, 7–36 mos	Milestones	
	Milestones: Gross Motor Skills, Atlas, 8–10 mos	Milestones	
	Milestones: Range of Motor Development, Yovani, 2–16 mos	Milestones	
	Milestones: Fine Motor Control, Atlas, 3–10 mos	Milestones	
	Second Year Fine Motor Development, Atlas, 20–32 mos	Milestones	
	Lifting the Head at 10 Weeks-1	Video	
	Lifting the Head at 10 Weeks-2	Video	
	Early Gross Motor Ability-Standing 1	Video	
	Early Gross Motor Ability-Standing 2	Video	
	Stand with Support	Video	
	Early Steps	Video	
	Walking with Support	Video	

Learning Objectives	Application Activities	Activity Type	Page Reference
	Gross Motor Ability at One Year	Video	pp. 162–164
	Gross Motor Development in the First Year	Video	
	Sucking Reflex at 2 Weeks	Video	
	Startle Reflex at 2 Weeks	Video	
	Moro Reflex at 2 Weeks	Video	
	Stepping Reflex at 2 Weeks	Video	
	Copying Shapes at Age 3-1	Video	
	Copying Shapes at Age 3-2	Video	
	Copying Shapes at Age 4-1	Video	
	Copying Shapes at Age 4-2	Video	
	Fine Motor Skills at Age 3	Video	
	Drawing Pictures at Age 4	Video	
	Fine Motor Skills at Age 5	Video	
	Handwriting	Milestones	
	Drawing	Milestones	
	Major Milestones in Motor Development	Sequencing	
	Motor Skills: Middle Childhood	Milestones	
	Motor Development Adolescence	Milestones: Transitions	
Outline the course of sensory and perceptual development.	Milestones: Visual Acuity, Colin, 1 wk–12 mos	Milestones	pp. 168–174
	Milestones: Sensorimotor, Yovani, 2–8 mos	Milestones	
	Milestones: Sound Sensitivity, Yovani, 2 mos–2 yrs	Milestones	
	Milestones: Development of Taste Perception, Amalia, 4–20 mos	Milestones	
	Ecological View of Perception, Kestrel, 6–9 mos	Milestones	
	Milestones: Sensation and Perception, Felana, 13–18 mos	Milestones	
	Milestones: Affordances, Felana, 13 mos–2 yrs	Milestones	
	Visual and Auditory Tracking at 3 Weeks	Video	
	Visual and Auditory Tracking at 10 Weeks	Video	
	Infant Perception	Video	
	Visual System Development in Infants	Interactive Exercise	
Discuss the connection between perception and action.	Milestones: Musical Understanding, Felana, 12–20 mos	Milestones	pp. 182–184