Lifted by his mother into a world of wonders, the baby responds with joy, determined to master his world. Research confirms that infants are remarkably capable beings who rapidly make sense of constantly changing sounds, shapes, patterns, and surfaces in their surroundings.

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Infancy: Early Learning, Motor Skills, and Perceptual Capacities

Enthralled with their new baby, Yolanda and Jay came to my child development class when Joshua was 4 weeks old to share their reactions to new parenthood. Holding little Joshua over his shoulder while patting him gently, Jay remarked, “When we first saw him—a tiny bundle with his arms and legs all scrunched up, so helpless looking—we worried, ‘How will we ever figure out how to meet his needs?’ To our surprise, almost immediately, Joshua was able to help us!”

Yolanda demonstrated by speaking softly to Joshua. “Look,” she said, “at the sound of our voices, his face perks up, and he turns toward us with rapt attention.” She touched his palm and continued, “Look at how his tiny hand grasps whatever comes near it—our fingers or the folds of our clothing—and how tightly he holds on.”

As Joshua snuggled against Jay’s chest, Jay noted, “When he’s unhappy, we hold him close so he can feel our heartbeats.” Joshua whimpered, so Jay began to walk around the room, “When he’s bored, we carry him to a new place and sing to him, and often that’s enough to quiet him. His cry is becoming a language we can understand.”

Jay placed Joshua on his tummy on a blanket-covered table. “See,” he announced proudly, “he lifts his head and shows off his strength with these shaky half push-ups.” When Jay turned Joshua on his back, the baby stared at Yolanda’s bright pink blouse, his face utterly absorbed. Lifting Joshua and giving him a kiss, Jay exclaimed, “We marvel at his determination to master his world!”

As Yolanda’s and Jay’s observations confirm, our view of infancy—the period of development that spans the first year of life—has changed drastically over the past century. At one time, the newborn, or neonate, was considered a passive, incompetent being whose world was, in the words of turn-of-the-twentieth-century psychologist William James, “a blooming, buzzing confusion.” Careful observations of infants’ behavior and more refined methods enabling researchers to test babies’ capacities confirm that, from the outset, infants are skilled, capable beings who display many complex abilities.

Infant development proceeds at an astonishing pace. Excited relatives who visit just after the birth and then return a few months later often remark that the baby does not seem like the same individual! Although researchers agree that infants are competent beings, fervent debates continue over questions like these: What capacities are present from the very beginning? Which mature with the passage of time? And which result from the baby’s constant interaction with her physical and social worlds? In this chapter, we explore the infant’s remarkable capabilities—early reflexes, ability to learn, motor skills, and perceptual capacities—and the debates that surround them.
The Organized Newborn

The newborn baby, as we saw in Chapter 3, is homely looking, with a head that appears too large in relation to the potbellied trunk and bowlegged lower body. In addition, the baby’s skin is usually wrinkled and “parboiled” in appearance. Yet a few hours spent with a neonate reveal a wide variety of capacities that are crucial for survival and that evoke care and attention from adults. In relating to their physical and social worlds, babies are active from the very start.

Reflexes

A reflex is an inborn, automatic response to a particular form of stimulation. Reflexes are the neonate’s most obvious organized patterns of behavior. A father, changing his newborn baby’s diaper, bumps the side of the table. The infant flings her arms wide and then brings them back toward her body. A mother softly strokes her infant’s cheek, and the baby turns his head in her direction. Table 4.1 lists the major newborn reflexes. See if you can identify the ones described here and in Joshua’s behavior in the introduction to this chapter. Then let’s consider the meaning and purpose of these curious behaviors.

Adaptive value of reflexes

Some reflexes have survival value. The rooting reflex helps a breastfed baby find the mother’s nipple. Babies display it only when hungry and

### Table 4.1 Some Newborn Reflexes

<table>
<thead>
<tr>
<th>Reflex</th>
<th>Stimulation</th>
<th>Response</th>
<th>Age of Disappearance</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye blink</td>
<td>Shine bright light at eyes or clap hand near head</td>
<td>Infant quickly closes eyelids</td>
<td>Permanent</td>
<td>Protects infant from strong stimulation</td>
</tr>
<tr>
<td>Rooting</td>
<td>Stroke cheek near corner of mouth</td>
<td>Head turns toward source of stimulation</td>
<td>3 weeks (becomes voluntary head turning at this time)</td>
<td>Helps infant find the nipple</td>
</tr>
<tr>
<td>Sucking</td>
<td>Place finger in infant’s mouth</td>
<td>Infant sucks finger rhythmically</td>
<td>Replaced by voluntary sucking after 4 months</td>
<td>Permits feeding</td>
</tr>
<tr>
<td>Swimming¹</td>
<td>Place infant face down in pool of water</td>
<td>Baby paddles and kicks in swimming motion</td>
<td>4–6 months</td>
<td>Helps infant survive if dropped into water</td>
</tr>
<tr>
<td>Moro</td>
<td>Hold infant horizontally on back and let head drop slightly, or produce a sudden loud sound against surface supporting infant</td>
<td>Infant makes an “embracing” motion by arching back, extending legs, throwing arms outward, and then bringing arms in toward the body</td>
<td>6 months</td>
<td>In human evolutionary past, may have helped infant cling to mother</td>
</tr>
<tr>
<td>Palmar grasp</td>
<td>Place finger in infant’s hand and press against palm</td>
<td>Spontaneous grasp of finger</td>
<td>3–4 months</td>
<td>Prepares infant for voluntary grasping</td>
</tr>
<tr>
<td>Tonic neck</td>
<td>Turn baby’s head to one side while infant is lying awake on back</td>
<td>Infant lies in a “fencing position.” One arm is extended in front of eyes on side to which head is turned, other arm is flexed</td>
<td>4 months</td>
<td>May prepare infant for voluntary reaching</td>
</tr>
<tr>
<td>Stepping</td>
<td>Hold infant under arms and permit bare feet to touch a flat surface</td>
<td>Infant lifts one foot after another in stepping response</td>
<td>2 months in infants who gain weight quickly; sustained in lighter infants</td>
<td>Prepares infant for voluntary walking</td>
</tr>
<tr>
<td>Babinski</td>
<td>Stroke sole of foot from toe toward heel</td>
<td>Toes fan out and curl as foot twists in</td>
<td>8–12 months</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

¹Placing infants in a pool of water is dangerous. See discussion on page 127.

touched by another person, not when they touch themselves (Rochat & Hespos, 1997). And if newborns could not suck, our species would be unlikely to survive for a single generation! At birth, babies adjust their sucking pressure to how easily milk flows from the nipple (Craig & Lee, 1999). The swimming reflex helps a baby who is accidentally dropped into water stay afloat, increasing the chances of retrieval by the caregiver.

Other reflexes probably helped babies survive during our evolutionary past. For example, the Moro, or “embracing,” reflex is believed to have helped infants cling to their mothers when they were carried about all day. If the baby happened to lose support, the reflex caused the infant to embrace and, along with the powerful grasp reflex (so strong during the first week that it can support the baby’s entire weight), regain its hold on the mother’s body (Kessen, 1967; Prechtl, 1958).

Several reflexes help parents and infants establish gratifying interaction. A baby who searches for and successfully finds the nipple, sucks easily during feedings, and grasps when her hand is touched encourages parents to respond lovingly and feel competent as caregivers. Reflexes can also help parents comfort the baby because they permit infants to control distress and amount of stimulation. As any new mother who remembers to bring a pacifier on an outing with her young baby knows, sucking helps quiet a fussy infant.

**REFLEXES AND THE DEVELOPMENT OF MOTOR SKILLS**

A few reflexes form the basis for complex motor skills that will develop later. For example, the tonic neck reflex may prepare the baby for voluntary reaching. When babies lie on their backs in this “fencing position,” they naturally gaze at the hand in front of their eyes. The reflex may encourage them to combine vision with arm movements and, eventually, reach for objects (Knobloch & Pasamanick, 1974).

Certain reflexes—such as the palmar grasp, swimming, and stepping—drop out of the infants’ behavioral repertoire early, but the motor functions involved are renewed later. The stepping reflex, for example, looks like a primitive walking response. In infants who gain weight quickly in the weeks after birth, the stepping reflex drops out because thigh and calf muscles are not strong enough to lift the baby’s increasingly chubby legs. But if the lower part of the infant’s body is dipped in water, the reflex reappears because the buoyancy of the water lightens the load on the baby’s muscles (Thelen, Fisher, & Ridley-Johnson, 1984). When the stepping reflex is exercised regularly, babies display more spontaneous stepping movements and gain muscle strength. Consequently, they tend to walk several weeks earlier than if stepping is not practiced (Zelazo et al., 1993). However, there is no special need for infants to practice the stepping reflex because all normal babies walk in due time.

In the case of the swimming reflex, trying to build on it is risky. Although young babies placed in a swimming pool will paddle and kick, they swallow large amounts of water. This lowers the concentration of salt in the baby’s blood, which can cause brain swelling and seizures. Despite this remarkable reflex, swimming lessons are best postponed until at least 3 years of age.
• THE IMPORTANCE OF ASSESSING REFLEXES • Look at Table 4.1 again, and you will see that most newborn reflexes disappear during the first 6 months. Researchers believe that this is due to a gradual increase in voluntary control over behavior as the cerebral cortex develops. Pediatricians test reflexes carefully, especially if a newborn has experienced birth trauma, because reflexes can reveal the health of the baby’s nervous system. Weak or absent reflexes, overly rigid or exaggerated reflexes, and reflexes that persist beyond the point in development when they should normally disappear can signal damage to the cerebral cortex (Schott & Rossor, 2003; Zafeiriou, 2000). However, individual differences in reflexive responses exist that are not cause for concern. An observer must assess newborn reflexes along with other characteristics to distinguish normal from abnormal central nervous system functioning (Touwen, 1984).

States
Throughout the day and night, newborn infants move in and out of five states of arousal, or degrees of sleep and wakefulness, described in Table 4.2. During the first month, these states alternate frequently. The most fleeting is quiet alertness, which usually moves quickly toward fussing and crying. Much to the relief of their fatigued parents, newborns spend the greatest amount of time asleep—about 16 to 18 hours a day (Davis, Parker, & Montgomery, 2004).

Between birth and 2 years, the organization of sleep and wakefulness changes substantially. The decline in total sleep time is not great; the average 2-year-old still needs 12 to 13 hours per day. The greatest changes are that periods of sleep and wakefulness become fewer but longer, and the sleep–wake pattern increasingly conforms to a circadian rhythm, or 24-hour schedule. Although at birth babies sleep more at night than during the day, their sleep–wake cycles are determined mostly by fullness–hunger (Goodlin-Jones, Burnham, & Anders, 2000). By 2 to 3 months, infants respond more to darkness–light. Babies of this age who are exposed to more bright sunlight—for example, through regular, early afternoon stroller rides—sleep better at night (Harrison, 2004) Between 6 and 9 months, daytime sleep typically declines to two naps. By 1½ years, most infants take just one nap. And around 4 to 5 years, napping subsides (Iglowstein et al., 2003).

Although these changing arousal patterns are due to brain development, they are affected by the social environment as well. In most Western nations, parents usually succeed in getting their babies to sleep through the night around 4 months of age by offering an evening feeding before putting them down in a separate, quiet room. In this way, they push young infants to the limits of their neurological capacities. Not until the middle of the first year is the secretion of melatonin, a hormone within the brain that promotes drowsiness, much greater at night than during the day (Sadeh, 1997).

As the Cultural Influences box on the following page reveals, the practice of isolating infants to promote sleep is rare elsewhere in the world. When babies sleep with their parents,

### TABLE 4.2 INFANT STATES OF AROUSAL

<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
<th>Daily Duration in Newborn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular, or NREM, sleep</td>
<td>The infant is at full rest and shows little or no body activity. The eyelids are closed, no eye movements occur, the face is relaxed, and breathing is slow and regular.</td>
<td>8–9 hours</td>
</tr>
<tr>
<td>Irregular, or REM, sleep</td>
<td>Gentle limb movements, occasional stirring, and facial grimacing occur. Although the eyelids are closed, occasional rapid eye movements can be seen beneath them. Breathing is irregular.</td>
<td>8–9 hours</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>The infant is either falling asleep or waking up. Body is less active than in irregular sleep but more active than in regular sleep. The eyes open and close; when open, they have a glazed look. Breathing is even but somewhat faster than in regular sleep.</td>
<td>Varies</td>
</tr>
<tr>
<td>Quiet alertness</td>
<td>The infant’s body is relatively inactive, with eyes open and attentive. Breathing is even.</td>
<td>2–3 hours</td>
</tr>
<tr>
<td>Waking activity and crying</td>
<td>The infant shows frequent bursts of uncoordinated body activity. Breathing is very irregular. Face may be relaxed or tense and wrinkled. Crying may occur.</td>
<td>1–4 hours</td>
</tr>
</tbody>
</table>

While awaiting the birth of a new baby, North American parents typically furnish a room as the infant’s sleeping quarters. For decades, child-rearing advice from experts has strongly encouraged the nighttime separation of baby from parent. For example, the most recent edition of Benjamin Spock’s *Baby and Child Care* recommends that babies be moved into their own room by 3 months of age, explaining, “By 6 months, a child who regularly sleeps in her parents’ room may become dependent on this arrangement” (Spock & Needlman, 2004, p. 60).

Yet parent–infant “cosleeping” is the norm for approximately 90 percent of the world’s population. Cultures as diverse as the Japanese, the Guatemalan Maya, the Inuit of northwestern Canada, and the Ikung of Botswana, Africa, practice it. Japanese and Korean children usually lie next to their mothers throughout infancy and early childhood, and many continue to sleep with a parent or other family member until adolescence (Takahashi, 1990; Yang & Hahn, 2002). Among the Maya, mother–infant cosleeping is interrupted only by the birth of a new baby, at which time the older child is moved next to the father or to another bed in the same room (Morelli et al., 1992). Cosleeping is also common in some North American groups. African-American children frequently fall asleep with their parents and remain with them for part or all of the night (Brenner et al., 2003). Appalachian children of eastern Kentucky typically sleep with their parents for the first 2 years (Abbott, 1992).

Cultural values—specifically, *collectivism versus individualism* (see Chapter 1, page 34)—strongly influence infant sleeping arrangements. In one study, researchers interviewed Guatemalan Mayan mothers and American middle-SES mothers about their sleeping practices. Mayan mothers stressed a collectivist perspective, explaining that cosleeping builds a close parent–child bond, which is essential for children to learn the ways of people around them. In contrast, American mothers conveyed an individualistic perspective, mentioning the importance of instilling early independence, preventing bad habits, and protecting their own privacy (Morelli et al., 1992).

Perhaps because more mothers are breastfeeding, during the past decade cosleeping increased from 6 to 13 percent among North American mothers and their infants (McKenna, 2002; Willinger et al., 2003). Research suggests that bedsharing evolved to protect infants’ survival and health. During the night, cosleeping babies breastfeed three times longer than infants who sleep alone. Because infants arouse to nurse more often when sleeping next to their mothers, some researchers believe that cosleeping may help safeguard babies at risk for sudden infant death syndrome (SIDS) (see From Research to Practice on page 312). In Asian cultures where cosleeping is the norm, including Cambodia, China, Japan, Korea, Thailand, and Vietnam, SIDS is rare (McKenna, 2002; Mosko, Richard, & McKenna, 1997a). And contrary to popular belief, mothers’ total sleep time is not decreased by cosleeping, although they experience a greater number of brief awakenings, which permit them to check on their baby (Mosko, Richard, & McKenna, 1997b).

Infant sleeping practices affect other aspects of family life. For example, sleep problems are not an issue for Mayan parents. Babies doze off in the midst of ongoing family activities and are carried to bed by their mothers. In contrast, for many North American parents, getting young children ready for bed often requires an elaborate ritual that takes a good part of the evening. Perhaps bedtime struggles, so common in North American homes but rare elsewhere in the world, are related to the stress young children feel when they are required to fall asleep without assistance (Latz, Wolf, & Lozoff, 1999).

Critics worry that cosleeping children will develop emotional problems, especially excessive dependency. Yet a longitudinal study following children from the end of pregnancy through age 18 showed that young people who had bedshared in the early years were no different from others in any aspect of adjustment (Okami, Weisner, & Olmstead, 2002). Another concern is that infants might become trapped under the parent’s body or in soft covers and suffocate. Parents who are obese or who smoke while bedsharing do pose a serious risk to their babies, as does the use of quilts and comforters (Willinger et al., 2003). But with appropriate precautions, parents and infants can cosleep safely. In cultures where cosleeping is widespread, parents and infants usually sleep with light covering on hard surfaces (such as firm mattresses, floor mats, and wooden planks), or infants sleep in a wicker basket placed between the parents or in a cradle or hammock next to the parents’ bed (McKenna, 2001, 2002; Nelson, Schiefenhoevel, & Haimerl, 2000).
their average sleep period remains constant at 3 hours from 1 to 8 months of age. Only at the end of the first year, as REM sleep (the state that usually prompts waking) declines, do infants move in the direction of an adultlike sleep—waking schedule (Ficca et al., 1999).

Even after infants sleep through the night, they continue to wake occasionally. In sleep observations and in surveys of parents in Australia, Israel, and the United States, night wakeings increased around 6 months and again between 1 1/2 and 2 years (Armstrong, Quinn, & Dadds, 1994; Scher, Epstein, & Tirosh, 2004; Scher et al., 1995). Around the middle of the first year, many infants encounter changes in caregiving routines, such as the mother’s return to work. And as Chapters 10 and 11 will reveal, the challenges of toddlerhood—the ability to range farther from the familiar caregiver and increased awareness of the self as separate from others—often prompt anxiety, evident in disturbed sleep and clinging. When parents offer comfort, these behaviors subside.

Although arousal states become more organized with age, striking individual differences in daily rhythms exist that affect parents’ attitudes toward and interactions with the baby. A few infants sleep for long periods at an early age, increasing the energy their well-rested parents have for sensitive, responsive care. Other babies cry a great deal, and their parents must exert great effort to soothe them. If these parents do not succeed, they may feel less competent and positive toward their infant. Babies who spend more time alert probably receive more social stimulation and opportunities to explore and, therefore, may be slightly advantaged in mental development (Gertner et al., 2002).

Of the states listed in Table 4.2, the two extremes of sleep and crying have been of greatest interest to researchers. Each tells us something about normal and abnormal early development.

**SLEEP** • Sleep is made up of at least two states. The expression “sleeping like a baby” was probably not meant to describe irregular, or rapid-eye-movement (REM) sleep, in which electrical brain-wave activity, measured with the EEG, is remarkably similar to that of the waking state. The eyes dart beneath the lids; heart rate, blood pressure, and breathing are uneven; and slight body movements occur. In contrast, during regular, or non-rapid-eye-movement (NREM) sleep, the body is almost motionless, and heart rate, breathing, and brain-wave activity are slow and regular.

Like children and adults, newborns alternate between REM and NREM sleep. However, as Figure 4.1 shows, they spend far more time in the REM state than they ever will again. REM sleep accounts for 50 percent of the newborn baby’s sleep time. By 3 to 5 years, it has declined to an adultlike level of 20 percent (Louis et al., 1997).

Why do young infants spend so much time in REM sleep? In older children and adults, the REM state is associated with dreaming. Babies probably do not dream, at least not in the same way we do. But researchers believe that the stimulation of REM sleep is vital for growth of the central nervous system. Young infants seem to have a special need for this stimulation because they spend so little time in an alert state, when they can get input from the environment. In support of this idea, the percentage of REM sleep is especially great in the fetus and in preterm babies, who are even less able than full-term newborns to take advantage of external stimulation (DiPietro et al., 1996; de Weerd & van den Bossche, 2003).

Whereas the brain-wave activity of REM sleep safeguards the central nervous system, the rapid eye movements protect the health of the eye. Eye movements cause the vitreous (gelatin-like substance within the eye) to circulate, thereby delivering oxygen to parts of
the eye that do not have their own blood supply. During sleep, when the eye and the vitreous are still, visual structures are at risk for anoxia. As the brain cycles through REM-sleep periods, rapid eye movements stir up the vitreous, ensuring that the eye is fully oxygenated (Blumberg & Lucas, 1996).

Because the normal sleep behavior of the newborn baby is organized and patterned, observations of sleep states can help identify central nervous system abnormalities. In infants who are brain damaged or who have experienced birth trauma, disturbed sleep cycles are often present, generally in the form of disorganized transitions between REM and NREM sleep that cannot be identified as a specific state. Babies with poor sleep organization are likely to be behaviorally disorganized and, therefore, to have difficulty learning and eliciting caregiver interactions that enhance their development (de Weerd & van den Bossche, 2003; Groome et al., 1997). And the brain-functioning problems that underlie newborn sleep irregularities may culminate in sudden infant death syndrome, a major cause of infant mortality (see the From Research to Practice box on page 132).

**Crying**

Crying is the first way that babies communicate, letting parents know that they need food, comfort, and stimulation. During the weeks after birth, all babies have some fussy periods when they are difficult to console. But most of the time, the nature of the cry, combined with the experiences leading up to it, helps guide parents toward its cause. The baby’s cry is a complex auditory stimulus that varies in intensity, from a whimper to a message of all-out distress (Gustafson, Wood, & Green, 2000). As early as the first few weeks of life, individual infants can be identified by the unique vocal “signature” of their cries, which helps parents locate the baby from a distance (Gustafson, Green, & Cleland, 1994).

Young infants usually cry because of physical needs, most commonly hunger, but babies may also cry in response to temperature change when undressed, a sudden noise, or a painful stimulus. An infant’s state also affects proneness to cry: A baby who, when quietly alert, regards a colorful or noise-making object with interest may burst into tears when confronted with the same object while in a state of mild discomfort. And newborns (as well as older infants) often cry at the sound of another crying baby (Dondi, Simion, & Caltran, 1999). Some researchers believe that this response reflects an inborn capacity to react to the suffering of others. Furthermore, as Figure 4.2 shows, crying typically increases during the early weeks, peaks at about 6 weeks, and then declines. Because this pattern appears in many cultures with vastly different infant care practices, researchers believe that normal readjustments of the central nervous system underlie it (Barr, 2001).
Millie awoke with a start one morning and looked at the clock. It was 7:30, and Sasha had missed her night waking and early morning feeding. Wondering if she was all right, Millie and her husband Stuart tiptoed into the room. Sasha lay still, curled up under her blanket. She had died silently during her sleep.

Sasha was a victim of sudden infant death syndrome (SIDS), the unexpected death, usually during the night, of an infant younger than 1 year of age that remains unexplained after thorough investigation. In industrialized nations, SIDS is the leading cause of infant mortality between 1 week and 12 months of age. It accounts for one-third of these deaths in the United States and one-fourth in Canada (Health Canada, 2002b; Martin et al., 2003).

Although the precise cause of SIDS is not known, its victims usually show physical problems from the very beginning. Early medical records of SIDS babies reveal higher rates of prematurity and low birth weight, poor Apgar scores, and limp muscle tone. Abnormal heart rate and respiration and disturbances in sleep–wake activity are also involved (Daley, 2004; Kato et al., 2003). At the time of death, many SIDS babies have a mild respiratory infection (Samuels, 2003). This seems to increase the chances of respiratory failure in an already vulnerable baby.

One hypothesis about the cause of SIDS is that problems in brain functioning prevent these infants from learning how to respond when their survival is threatened—for example, when respiration is suddenly interrupted. Between 2 and 4 months, when SIDS is most likely to occur, reflexes decline and are replaced by voluntary, learned responses. Respiratory and muscular weaknesses may stop SIDS babies from acquiring behaviors that replace defensive reflexes (Lipsitt, 2003). As a result, when breathing difficulties occur during sleep, the infants do not wake up, shift their position, or cry out for help. Instead, they simply give in to oxygen deprivation and death. In support of this interpretation, autopsies reveal that SIDS babies, more often than other infants, show structural and chemical abnormalities in brain centers controlling breathing (Kinney et al., 2003; Sawaguchi et al., 2003).

In an effort to reduce the occurrence of SIDS, researchers are studying environmental factors related to it. Maternal cigarette smoking, both during and after pregnancy, as well as smoking by other caregivers, strongly predicts the disorder. Babies exposed to cigarette smoke have more respiratory infections and are two to four times as likely as nonexposed infants to die of SIDS (Sundell, 2001). Prenatal abuse of drugs that depress central nervous system functioning (opiates and barbiturates) increases the risk of SIDS tenfold (Kandall et al., 1993). SIDS babies also are more likely to sleep on their stomachs than on their backs, and they more often lie on soft bedding and are wrapped warmly in clothing and blankets (Hauck et al., 2003).

Researchers suspect that nicotine, depressant drugs, excessive body warmth, and respiratory infection all lead to physiological stress, which disrupts the normal sleep pattern. When sleep-deprived infants experience a sleep “rebound,” they sleep more deeply, which results in loss of muscle tone in the airway passages. In at-risk babies, the airway may collapse, and the infant may fail to arouse sufficiently to reestablish breathing (Simpson, 2001). In other cases, healthy babies sleeping face down on soft bedding may die from continually breathing their own exhaled breath.

Quitting smoking, changing an infant’s sleeping position, and removing a few bedclothes can reduce the incidence of SIDS. For example, if women refrained from smoking while pregnant, an estimated 30 percent of SIDS would be prevented. Over the past decade, public education campaigns that discourage parents from putting babies down on their stomachs have cut the incidence of SIDS in half in many Western nations (Byard & Krous, 2003). Nevertheless, compared with white infants, SIDS rates are two to six times as high in poverty-stricken minority groups, where parental stress, substance abuse, reduced access to health care, and lack of knowledge about safe sleep practices are widespread (Kinney et al., 2003; Unger et al., 2003).

When SIDS does occur, surviving family members require a great deal of help to overcome a sudden and unexpected death. As Millie commented 6 months after Sasha died, “It’s the worst crisis we’ve ever been through. What’s helped us most are the comforting words of others who’ve experienced the same tragedy.”
Adult Responsiveness to Infant Cries. The next time you hear a baby cry, notice your own reaction. The sound stimulates strong feelings of arousal and discomfort in men and women, parents and nonparents alike (Murray, 1985). This powerful response is probably innately programmed in all humans to make sure that babies receive the care and protection they need to survive.

Although parents do not always interpret the baby’s cry correctly, their accuracy improves with experience. As babies get older, parents react to more subtle cues in the cry—not just intensity but also whimpering and calling sounds (Thompson & Leger, 1999). These cues, together with the context of the cry, help them figure out what is wrong. If the baby has not eaten for several hours, she is likely to be hungry. If a period of wakefulness and stimulation preceded the cry, the infant may be tired. A sharp, piercing, sustained cry usually means the baby is in pain and prompts caregivers to rush to the infant. Very intense cries are rated as more unpleasant and produce greater physiological arousal in adults (Crowe & Zeskind, 1992). These adaptive reactions help ensure that an infant in danger will quickly get help.

At the same time, parents vary widely in responsiveness. In one laboratory study, parents viewed videotapes of an infant moving from fussing to vigorous crying. Some said they would respond within 20 seconds, whereas others indicated they would wait several minutes. Parents who scored high in empathy (ability to take the perspective of others in distress) and who held “child-centered” attitudes toward infant care (for example, believed that babies cannot be spoiled by being picked up) were more likely to respond quickly to infant crying (Zeifman, 2003). In another study, mothers who believed that they could easily control the crying of an artificial baby (whose quieting was unrelated to the mother’s behavior) had difficulty detecting changes in cry sounds, engaged in less sensitive infant care, and had babies who developed into uncooperative toddlers (Donovan, Leavitt, & Walsh, 1997, 2000). The internal state of these mothers—who reacted defensively when they couldn’t calm the artificial baby—seemed to interfere with their ability to cope effectively with infant crying.

Soothing a Crying Infant. Fortunately, there are many ways to soothe a crying baby when feeding and diaper changing do not work (see Applying What We Know on page 134). The technique that Western parents usually try first, lifting the infant to the shoulder and rocking or walking, is most effective.

Another common soothing method is swaddling—wrapping the baby snugly in a blanket. The Quechua, who live in the cold, high-altitude desert regions of Peru, dress young babies in several layers of clothing and blankets that cover the head and body. The result—a warm pouch placed on the mother’s back that moves rhythmically as she walks—reduces crying and promotes sleep. It also allows the baby to conserve energy for early growth in the harsh Peruvian highlands (Tronick, Thomas, & Daltabuit, 1994).

Will reacting promptly and consistently to infant cries give babies a sense of confidence that their needs will be met and, over time, reduce fussing and complaining? Or will it strengthen crying behavior and produce a miniature tyrant? Answers are contradictory.

According to ethological theory, parental responsiveness is adaptive in that it ensures that the infant’s basic needs will be met (see Chapter 1, pages 24–25). At the same time, it brings the baby into close contact with the caregiver, who encourages the infant to communicate through means other than crying. In support of this view, two studies showed that mothers who were slow or failed to respond to their young baby’s cries had infants who cried more at the end of the first year (Bell & Ainsworth, 1972; Hubbard & van Ijzendoorn, 1991). Furthermore, in many tribal and village societies and non-Western developed nations, infants are in physical contact with their caregivers nearly continuously. Among the !Kung of Botswana, Africa, mothers sling their babies on their hips, so the infants can see their surroundings and nurse at will. Japanese mothers and infants also spend much time in close body contact (Small, 1998). Infants in these cultures show shorter bouts of crying than North American babies (Barr, 2001).
But not all research indicates that rapid parental responsiveness reduces infant crying (van IJzendoorn & Hubbard, 2000). The conditions that prompt crying are complex, and parents must make reasoned choices about what to do on the basis of culturally accepted practices, the suspected reason for the cry, and the context in which it occurs—for example, in the privacy of their own home or while having dinner at a restaurant. Fortunately, with age, crying declines and occurs more often for psychological (demands for attention, expressions of frustration) than physical reasons. Virtually all researchers agree that parents can lessen older babies’ need to cry by encouraging more mature ways of expressing their desires, such as gestures and vocalizations.

Abnormal Crying. Like reflexes and sleep patterns, the infant’s cry offers a clue to central nervous system distress. The cries of brain-damaged babies and those who have experienced prenatal and birth complications are often shrill, piercing, and shorter in duration than those of healthy infants (Boukydis & Lester, 1998; Green, Irwin, & Gustafson, 2000). Even neonates with a fairly common problem—colic, or persistent crying—tend to have high-pitched, harsh-sounding cries (Zeskind & Barr, 1997). Although the cause of colic is unknown, certain newborns, who react especially strongly to unpleasant stimuli, are susceptible. Because their crying is intense, they have more difficulty calming down than other babies. Colic generally subsides between 3 and 6 months (Barr & Gunnar, 2000; St James-Roberts et al., 2003).

Most parents try to respond to a crying baby’s call for help with extra care and attention, but sometimes the cry is so unpleasant and the infant so difficult to soothe that parents become frustrated, resentful, and angry. Preterm and ill babies are more likely to be abused by highly stressed parents, who sometimes mention a high-pitched, grating cry as one factor that disrupted their empathic feelings and caused them to lose control and harm the baby (Zeskind & Lester, 2001). We will discuss a host of additional influences on child abuse in Chapter 14.

Neonatal Behavioral Assessment

A variety of instruments enable doctors, nurses, and researchers to assess the organized functioning of newborn babies. The most widely used of these tests, T. Berry Brazelton’s Neonatal Behavioral Assessment Scale (NBAS), evaluates the baby’s reflexes, state changes, responsiveness to physical and social stimuli, and other reactions (Brazelton & Nugent, 1995). A major

<table>
<thead>
<tr>
<th>Technique</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lift the baby to the shoulder and rock or walk.</td>
<td>This provides a combination of physical contact, upright posture, and motion. It is the most effective soothing technique, causing young infants to become quietly alert.</td>
</tr>
<tr>
<td>Swaddle the baby.</td>
<td>Restricting movement and increasing warmth often soothe an infant.</td>
</tr>
<tr>
<td>Offer a pacifier, preferably sweetened with a sugar solution.</td>
<td>Sucking helps babies control their own level of arousal. Sucking a sweetened pacifier relieves pain and quiets a crying infant.</td>
</tr>
<tr>
<td>Talk softly or play rhythmic sounds.</td>
<td>Continuous, monotonous, rhythmic sounds (such as a clock ticking, a fan whirring, or peaceful music) are more effective than intermittent sounds.</td>
</tr>
<tr>
<td>Take the baby for a short car ride or a walk in a baby carriage; swing the baby in a cradle.</td>
<td>Gentle, rhythmic motion of any kind helps lull the baby to sleep.</td>
</tr>
<tr>
<td>Massage the baby’s body.</td>
<td>Stroke the baby’s torso and limbs with continuous, gentle motions. This technique is used in some non-Western cultures to relax the baby’s muscles.</td>
</tr>
<tr>
<td>Combine several methods just listed.</td>
<td>Stimulating several of the baby’s senses at once is often more effective than stimulating only one.</td>
</tr>
<tr>
<td>If these methods do not work, let the baby cry for a short period.</td>
<td>Occasionally, a baby responds well to just being put down and will, after a few minutes, fall asleep.</td>
</tr>
</tbody>
</table>

Sources: Blass, 1999; Campos, 1989; Lester, 1985; Reisman, 1987.
goal is to understand each infant’s capacity to initiate caregiver support and to adjust his or her behavior to avoid being overwhelmed by stimulation.

The NBAS has been given to many infants around the world. As a result, researchers have learned a great deal about individual and cultural differences in newborn behavior and how child-rearing practices can maintain or change a baby’s reactions. For example, NBAS scores of Asian and Native-American babies reveal that they are less irritable than Caucasian infants. Mothers in these cultures often encourage their babies’ calm dispositions through swaddling, close physical contact, and nursing at the first signs of discomfort (Chisholm, 1989; Freedman & Freedman, 1969; Murett-Wagstaff & Moore, 1989). In contrast, maternal care quickly changes the poor NBAS scores of undernourished infants in Zambia, Africa. The Zambian mother carries her baby about all day, providing a rich variety of sensory stimulation. As a result, a once unresponsive newborn becomes an alert, contented 1-week-old (Brazelton, Koslowski, & Tronick, 1976).

Can you tell from these examples why a single NBAS score is not a good predictor of later development? Because newborn behavior and parenting styles combine to influence development, changes in NBAS scores over the first week or two of life (rather than a single score) provide the best estimate of the baby’s ability to recover from the stress of birth. NBAS “recovery curves” predict normal brain functioning (as assessed by EEG and fMRI), intelligence, and absence of emotional and behavior problems with moderate success well into the preschool years (Brazelton, Nugent, & Lester, 1987; Ohgi et al., 2003a, 2003b).

The NBAS also has been used to help parents get to know their infants. In some hospitals, health professionals discuss with or demonstrate to parents the newborn capacities assessed by the NBAS. Parents of both preterm and full-term newborns who participate in these programs interact more effectively with their babies (Eiden & Reifman, 1996). In one study, Brazilian mothers who experienced a 50-minute NBAS-based discussion a few days after delivery were more likely than controls who received only health care information to establish eye contact, smile, vocalize, and soothe in response to infant signals a month later (Wendland-Carro, Piccinini, & Millar, 1999). Although lasting effects on development have not been demonstrated, NBAS interventions are useful in helping the parent–infant relationship get off to a good start.

**Learning Capacities**

*Learning* refers to changes in behavior as the result of experience. Babies come into the world with built-in learning capacities that permit them to profit from experience immediately. Infants are capable of two basic forms of learning, which were introduced in Chapter 1: classical and operant conditioning. In addition, they learn through their natural preference for novel stimulation. Finally, shortly after birth, babies learn by observing others; they can soon imitate the facial expressions and gestures of adults.

- **CLASSICAL CONDITIONING** - Newborn reflexes make classical conditioning possible in the young infant. In this form of learning, a neutral stimulus is paired with a stimulus that leads to a reflexive response. Once the baby’s nervous system makes the connection between the two stimuli, the new stimulus will produce the behavior by itself.

  Classical conditioning is of great value to human infants because it helps them recognize which events usually occur together in the everyday world. As a result, they can anticipate what is about to happen next, and the environment becomes more orderly and predictable. Let’s take a closer look at the steps of classical conditioning.

  Imagine a mother who gently strokes her infant’s forehead each time she settles down to nurse the baby. Soon the mother notices that each time the baby’s forehead is stroked, he makes active sucking movements. The infant has been classically conditioned. Here is how it happened (see Figure 4.3 on page 136):

  - Before learning takes place, an unconditioned stimulus (UCS) must consistently produce a reflexive, or unconditioned, response (UCR). In our example, the stimulus of sweet breast milk (UCS) resulted in sucking (UCR).
To produce learning, a *neutral stimulus* that does not lead to the reflex is presented at about the same time as the UCS. Ideally, the neutral stimulus should occur just before the UCS. The mother stroked the baby’s forehead as each nursing period began. The stroking (neutral stimulus) was paired with the taste of milk (UCS).

If learning has occurred, the neutral stimulus by itself produces a response similar to the reflexive response. The neutral stimulus is then called a *conditioned stimulus (CS)*, and the response it elicits is called a *conditioned response (CR)*. We know that the baby has been classically conditioned because stroking his forehead outside the feeding situation (CS) results in sucking (CR).

If the CS is presented alone enough times, without being paired with the UCS, the CR will no longer occur, an outcome called **extinction**. In other words, if the mother strokes the infant’s forehead again and again without feeding him, the baby will gradually stop sucking in response to stroking.

Young infants can be classically conditioned most easily when the association between two stimuli has survival value. Thus they learn quickly in the feeding situation, since learning which stimuli regularly accompany feeding improves the infant’s ability to get food and survive (Blass, Ganchrow, & Steiner, 1984). In contrast, some responses, such as fear, are very difficult to classically condition in young babies. Until infants have the motor skills to escape unpleasant events, they have no biological need to form these associations. After 6 months of age, however, fear is easy to condition, as seen in the famous example of little Albert, conditioned by John Watson to withdraw and cry at the sight of a furry white rat. Return to Chapter 1, page 19, to review this well-known study. Then test your knowledge of classical conditioning by identifying the UCS, UCR, CS, and CR in Watson’s study. In Chapter 10, we will discuss the development of fear, as well as other emotional reactions.

**OPERANT CONDITIONING** • In classical conditioning, babies build expectations about stimulus events in the environment, but their behavior does not influence the stimuli that occur. In **operant conditioning**, infants act (or *operate*) on the environment, and the stimuli that follow their behavior change the probability that the behavior will occur again. A stimulus
that increases the occurrence of a response is called a reinforcer. For example, sweet liquid reinforces the sucking response in newborn babies. Removing a desirable stimulus or presenting an unpleasant one to decrease the occurrence of a response is called punishment.

Because the young infant can control only a few behaviors, successful operant conditioning in the early weeks is limited to head-turning and sucking responses. But many stimuli besides food can serve as reinforcers. For example, researchers have created special laboratory conditions in which the baby’s rate of sucking on a nipple produces a variety of interesting sights and sounds. Newborns will suck faster to see visual designs or to hear music and human voices (Floccia, Christophe, & Bertoncini, 1997). Even preterm babies will seek reinforcing stimulation. In one study, they increased their contact with a soft teddy bear that “breathed” at a rate reflecting the infant’s respiration, whereas they decreased their contact with a nonbreathing bear (Thoman & Ingersoll, 1993). As these findings suggest, operant conditioning has become a powerful tool for finding out what stimuli babies can perceive and which ones they prefer.

As infants get older, operant conditioning includes a wider range of responses and stimuli. For example, researchers have hung mobiles over the cribs of 2- to 6-month-olds. When the baby’s foot is attached to the mobile with a long cord, the infant can, by kicking, make the mobile turn. Under these conditions, it takes only a few minutes for the infant to start kicking vigorously. This technique has yielded important information about infant memory. In a series of studies, Carolyn Rovee-Collier found that 3-month-olds remembered how to activate the mobile 1 week after training. By 6 months, memory increases to 2 weeks (Rovee-Collier, 1999; Rovee-Collier & Bhatt, 1993). Around the middle of the first year, babies can manipulate switches or buttons to control stimulation. When 6- to 18-month-olds pressed a lever to make a toy train move around a track, duration of memory continued to increase with age; 13 weeks after training, 18-month-olds still remembered how to press the lever (Hartshorn et al., 1998b). Figure 4.4 shows this dramatic rise in retention of operant responses over the first year and a half.

Even after 3- to 6-month-olds forget an operant response, they need only a brief prompt—an adult who shakes the mobile—to reinstate the memory (Hildreth & Rovee-Collier, 2002). And when 6-month-olds are given a chance to reactivate the response themselves for just a couple of minutes—jigging the mobile by kicking or moving the train by lever-pressing—their memory not only returns but extends further, to about 17 weeks (Hildreth, Sweeney, & Rovee-Collier, 2003). Perhaps permitting the baby to generate the previously learned behavior strengthens memory because it re-exposes the child to more aspects of the original learning situation.

At first, infants’ memory for operant responses is highly context dependent. If 2- to 6-month-olds are not tested in the same situation in which they were trained—with the same mobile and crib bumper and in the same room—they remember poorly (Boller, Grabelle, & Rovee-Collier, 1995; Hayne & Rovee-Collier, 1995). After 9 months, the importance of context declines. Older infants and toddlers remember how to make the toy train move even when its features are altered and testing takes place in a different room (Hartshorn et al., 1998a; Hayne, Boniface, & Barr, 2000). As babies move on their own and experience frequent changes in context, their memory for responses that lead to interesting consequences becomes increasingly context free. They apply those responses more flexibly, generalizing them to relevant new situations.

As Chapter 6 will make clear, operant conditioning has also been used to study babies’ ability to group similar stimuli into categories. It plays a vital role in the formation of social relationships as well. As the baby gazes into the adult’s eyes, the adult looks and smiles back, and then the infant looks and smiles again. The behavior of each partner reinforces the other, and both continue their pleasurable interaction. In Chapter 10, we will see that this contingent responsiveness contributes to the development of infant–caregiver attachment.
• HABITUATION • At birth, the human brain is set up to be attracted to novelty. Infants tend to respond more strongly to a new element that has entered their environment. Habituation refers to a gradual reduction in the strength of a response due to repetitive stimulation. Looking, heart rate, and respiration rate may all decline, indicating a loss of interest. Once this has occurred, a new stimulus—a change in the environment—causes the habituated response to return to a high level, an increase called recovery. For example, when you walk through a familiar space, you notice things that are new or different—a recently purchased picture on the wall, a piece of furniture that has been moved. Habituation and recovery make learning more efficient by enabling us to focus our attention on those aspects of the environment we know least about.

Window into Early Attention, Memory, and Knowledge. More than any other learning capacity, researchers rely on habituation and recovery to explore infants’ understanding of the world. For example, a baby who first habituates to a visual pattern (a photo of a baby), then recovers to a new one (a photo of a bald man), appears to remember the first stimulus and perceive the second one as new and different from it. This method of studying infant attention, perception, and memory, illustrated in Figure 4.5a, can be used with newborn babies, even those who are preterm. It has even been used to study the fetus’s sensitivity to external stimuli—for example, by measuring changes in fetal heart rate when various repeated sounds are presented (Hepper, 1997).

Preterm and newborn babies require a long time to habituate and recover to novel visual stimuli—about 3 or 4 minutes. But by 4 or 5 months, they require as little as 5 to 10 seconds to take in a complex visual stimulus and recognize it as different from a previous one. Yet a fascinating exception to this trend exists. Two-month-olds actually take longer to habituate to novel visual forms than do newborns and older infants (Colombo, 2002). Later we will see that 2 months is also a time of dramatic gains in visual perception. Perhaps when young babies are first able to perceive certain information, they require more time to take it in. Another contributor to the long habituation times of young babies is their difficulty disengaging attention from a stimulus. By 4 months, attention becomes more flexible—a change believed to be due to development of brain structures controlling eye movements (Johnson, 1996). (Nevertheless, as will be apparent shortly, a few babies continue to have trouble shifting attention.)

Recovery, or novelty preference, assesses infants’ recent memory. Think about what happens when you return to a place you have not seen for a long time. Instead of attending to novelty, you are likely to focus on aspects that are familiar, remarking, “I recognize that. I’ve been here before!” Similarly, with passage of time, infants shift from a novelty preference to a familiarity preference. That is, they recover to the familiar stimulus rather than to a novel stimulus (see Figure 4.5b) (Bahrick & Pickens, 1995; Courage & Howe, 1998). By capitalizing on that shift, researchers can use habituation to assess remote memory, or memory for stimuli to which infants were exposed weeks or months earlier.

Habituation studies show that from the constantly changing flow of objects, actions, and events in their surroundings, infants detect and remember an extraordinarily wide range of stimuli. They are especially attentive to the movements of objects and people, and they retain such information over many weeks. In one study, 5½-month-old babies habituated to a video in which they saw the face of a woman performing an action (either brushing teeth, blowing bubbles, or brushing...
In a test phase 1 minute later and again after a 7-week delay, infants watched the familiar video next to a novel video, in which the action changed while the woman's face remained the same. As Figure 4.6 indicates, infants clearly remembered the action. At 1 minute, most showed a novelty preference; they looked longer at the novel action than the familiar action. But at 7 weeks, most showed a familiarity preference, looking longer at the familiar action than the new action. These findings reveal that young infants remember human actions for an impressively long time. (Adapted from Bahrick, Gogate, & Ruiz, 2002.)

These findings, and others in this chapter, confirm that infants find motion especially captivating—so much so that they attend to and remember an action far better than the features of a woman while she performed an action, such as brushing teeth. In two test phases, they saw the familiar video next to a novel video, in which the action changed—for example, to brushing hair—while the woman’s face remained the same.

In the immediate test phase (1 minute later), which assessed recent memory, infants displayed a novelty preference; they looked longer at the novel action than the familiar action. In the delayed test phase (7 weeks later), which assessed remote memory, infants showed a familiarity preference; they looked longer at the familiar action than the novel action. These findings reveal that young infants remember human actions for an impressively long time. (Adapted from Bahrick, Gogate, & Ruiz, 2002.)
of the person engaging in it! Later we also will see that babies are excellent at discriminating faces in static displays (such as the one in Figure 4.5). However, infants’ memory for the faces of unfamiliar people and for other static patterns is short-lived—at 3 months, only about 24 hours, and at the end of the first year, several days to a few weeks (Fagan, 1973; Pascalis, de Haan, & Nelson, 1998). In comparison, 3-month-olds’ memory for the unusual movements of objects (such as a metal nut on the end of a string swinging back and forth) persists for at least 3 months (Bahrick, Hernandez-Reif, & Pickens, 1997).

Note that in habituation research, infants retain certain information over much longer time spans than they do in the operant conditioning studies using the crib mobile (refer again to Figure 4.4 on page 137). Clearly, infants learn and remember a great deal just by watching objects and events around them. They need not be physically active to acquire new information (although, as will become clear later, motor activity facilitates certain aspects of perception and cognition).

Habituation has been used to assess a wide range of infant perceptual and cognitive capacities—speech perception, musical and visual pattern perception, object perception, categorization, and knowledge of many aspects of the social world. These studies reveal yet another disparity with operant conditioning research: When assessed through habituation, infant learning is not as context dependent. In this and subsequent chapters, we will see many examples of infants’ detection of relationships—for example, speech sounds that often occur together, objects that belong to the same category, and the match between an object’s rhythm and tempo of movement and its sounds. As early as 3½ months, infants use their current awareness of relationships to make sense of new information (Bahrick, 2002).

Despite the many strengths of habituation research, its findings are not clear-cut. When looking, sucking, or heart rate declines and recovers, it is sometimes uncertain what babies actually know about the stimuli to which they responded. We will return to this difficulty in Chapter 6.

Habituation and Later Mental Development. Individual differences in babies’ habituation performance have long-term significance. Habituation and recovery to visual stimuli are among the earliest available predictors of intelligence in childhood and adolescence. Correlations between the speed of these responses in infancy and the mental test scores of 3- to 18-year-olds consistently range from the .30s to the .60s (McCall & Carriger, 1993; Sigman, Cohen, & Beckwith, 1997).

Habituation and recovery seem to be an especially effective early index of intelligence because they assess quickness and flexibility of thinking, which underlie intelligent behavior at all ages. Compared with infants who habituate and recover quickly, infants who are “long lookers” on these tasks have difficulty redirecting their attention from one spot to another. Instead of taking in the overall arrangement of a stimulus followed by its finer details, they get stuck on certain small features. As a result, they process much less information (Colombo, 2002; Colombo et al., 2004). When researchers induced 5-month-old long lookers to take in a complex design by successively illuminating each of its parts with a red light, the babies changed their approach and scanned visual stimuli just as “short lookers” do. As a result, their capacity to discriminate and remember visual stimuli in habituation tasks improved (Jankowski, Rose, & Feldman, 2001). Investigators have yet to explore the impact of such early intervention on intellectual development.

So far, we have considered only one type of memory—recognition. It is the simplest form of memory: All the baby has to do is indicate (by looking, kicking, or pressing a lever) whether a new stimulus is identical or similar to a previous one. Recall is a second, more challenging form of memory that involves remembering something not present. Can infants engage in recall? By the end of the first year, they can, as indicated by their ability find hidden objects and imitate the actions of others hours or days after they observed the behavior. We will take up recall in Chapter 7.
Newborn babies come into the world with a primitive ability to learn through imitation—by copying the behavior of another person. Figure 4.7 shows infants from 2 days to several weeks old imitating adult facial expressions (Field et al., 1982; Meltzoff & Moore, 1977). The human newborn’s capacity to imitate extends to certain gestures, such as head movements, and has been demonstrated in many ethnic groups and cultures (Meltzoff & Kuhl, 1994). As the figure reveals, even the newborns of chimpanzees, our closest evolutionary ancestors, imitate some facial expressions: tongue protrusion, mouth opening, and lip protrusion (Myowa-Yamakoshi et al., 2004).

But a few studies have failed to reproduce the human findings (see, for example, Anisfeld et al., 2001). And imitation is more difficult to induce in babies 2 to 3 months old than just after birth. Therefore, some investigators regard the capacity as little more than an automatic response that declines with age, much like a reflex. Others claim that newborns imitate a variety of facial expressions and head movements with apparent effort and determination, even after short delays—when the adult is no longer demonstrating the behavior. Furthermore, these investigators argue, imitation does not decline, as reflexes do. Human babies several months old often do not imitate an adult’s behavior right away because they try to play social games they are used to in face-to-face interaction—mutual gazing, cooing, smiling, and waving their arms. When an adult models a gesture repeatedly, older human infants soon get down to business and imitate (Meltzoff & Moore, 1994). Similarly, imitation declines in baby chimps around 9 weeks of age, when mother–baby mutual gazing and other face-to-face exchanges increase.

According to Andrew Meltzoff, newborns imitate in much the same way older children and adults do—by actively trying to match body movements they see with ones they feel themselves.
make (Meltzoff & Decety, 2003; Meltzoff & Moore, 1999). Later we will encounter evidence that young infants are surprisingly good at coordinating information across sensory systems. Still, Meltzoff and Moore’s view of newborn imitation as a flexible, voluntary capacity remains controversial.

As we will see in Chapter 6, infants’ capacity to imitate improves greatly over the first 2 years. But however limited it is at birth, imitation may reflect the baby’s deep-seated need to communicate (Blasi & Bjorklund, 2003). It is also a powerful means of learning. Using imitation, infants explore their social world, getting to know people by matching behavioral states with them. In the process, babies notice similarities between their own actions and those of others and start to find out about themselves. Furthermore, by tapping into infants’ ability to imitate, adults can get infants to express desirable behaviors; once they do, adults can encourage these further. Finally, caregivers take great pleasure in a baby who imitates their facial gestures and actions. Newborn imitation clearly seems one of those capacities that helps get the infant’s relationship with parents off to a good start.

**PART II • FOUNDATIONS OF DEVELOPMENT**

**Ask Yourself**

| REVIEW | What functions does REM sleep serve in young infants? Can sleep and crying tell us about the health of the baby’s central nervous system? Explain. |
| REVIEW | Provide an example of classical conditioning, of operant conditioning, and of habituation in young infants. Why is each type of learning useful? Cite differences between operant conditioning and habituation findings on infant memory. |
| APPLY | After a difficult birth, 2-day-old Kelly scores poorly on the NBAS. How would you address her mother’s concern that Kelly might not develop normally? |
| CONNECT | How do the diverse capacities of newborn babies contribute to their first social relationships? List as many examples as you can. |

**Motor Development in Infancy**

Virtually all parents eagerly await mastery of new motor skills, recording with pride when their infants hold up their heads, reach for objects, sit by themselves, and walk alone. Parents’ enthusiasm for these achievements makes perfect sense. With each new motor skill, babies master their bodies and the environment in a new way. For example, sitting upright gives infants an entirely different perspective on the world. Reaching enables babies to find out about objects by acting on them. And when infants can move on their own, their opportunities for exploration multiply.

Babies’ motor achievements have a powerful impact on their social relationships. Once infants can crawl, parents start to restrict their activities by saying “no” and expressing mild anger and impatience. Walking often brings the first “testing of wills” (Biringen et al., 1995). Despite her parents’ warnings, one newly walking 12-month-old continued to pull items from shelves that were off limits. “I said not to do that!” her mother remarked as she repeatedly took the infant by the hand and redirected her activities.

At the same time, parents increase their expressions of affection and playful activities as their independently moving baby seeks them out for greetings, hugs, and a gleeful game of hide-and-seek (Campos, Kermoian, & Zumbahlen, 1992). Certain motor skills, such as reaching and pointing, permit infants to communicate more effectively. Finally, babies’ delight—laughing, smiling, and babbling—as they work on new motor competencies triggers pleasurable reactions in others, which encourage infants’ efforts further (Mayes & Zigler, 1992). Motor skills, emotional and social competencies, cognition, and language develop together and support one another.

**The Sequence of Motor Development**

*Gross motor development* refers to control over actions that help infants get around in the environment, such as crawling, standing, and walking. In contrast, *fine motor development* has to
do with smaller movements, such as reaching and grasping. The Milestones table above shows the average ages at which infants and toddlers achieve a variety of gross and fine motor skills. Notice that this table also presents the age ranges during which the majority of infants accomplish each skill. Although the sequence of motor development is fairly uniform, large individual differences exist in rate of motor progress. Also, a baby who is a late reacher is not necessarily going to be a late crawler or walker. We would be concerned about a child’s development only if many motor skills were seriously delayed.

Look at the table once more, and you will see organization and direction in infants’ motor achievements. A cephalocaudal trend, or head-to-tail sequence, is evident: Motor control of the head comes before control of the arms and trunk, which comes before control of the legs. You can also see a proximodistal trend, meaning from the center of the body outward: Head, trunk, and arm control is advanced over coordination of the hands and fingers. Physical growth follows a cephalocaudal and proximodistal course during the prenatal period, infancy, and childhood (see Chapter 5). The similarities between physical and motor development suggest a genetic contribution to motor progress. As we will see, however, some motor milestones deviate sharply from these trends.

We must be careful not to think of motor skills as unrelated accomplishments that follow a fixed maturational timetable. Instead, each skill is a product of earlier motor attainments and a contributor to new ones. Furthermore, children acquire motor skills in highly individual ways. For example, most babies crawl before they pull to a stand and walk. Yet one infant I know, who
disliked being placed on her tummy but enjoyed sitting and being held upright, pulled to a stand and walked before she crawled!

Many influences—both internal and external to the child—support the vast transformations in motor competencies of the first 2 years. The dynamic systems perspective, introduced in Chapter 1 (see page 29), helps us understand how motor development takes place.

Motor Skills as Dynamic Systems

According to the dynamic systems theory of motor development, mastery of motor skills involves acquiring increasingly complex systems of action. When motor skills work as a system, separate abilities blend together, each cooperating with others to produce more effective ways of exploring and controlling the environment. For example, control of the head and upper chest are combined into sitting with support. Kicking, rocking on all fours, and reaching combine to become crawling. Then crawling, standing, and stepping unite into walking (Thelen, 1989).

Each new skill is a joint product of the following factors: (1) central nervous system development, (2) movement capacities of the body, (3) the goal the child has in mind, and (4) environmental supports for the skill. Change in any element makes the system less stable, and the child starts to explore and select new, more effective motor patterns.

The factors that induce change vary with age. In the early weeks of life, brain and body growth are especially important as infants achieve control over the head, shoulders, and upper torso. Later, the baby’s goals (getting a toy or crossing the room) and environmental supports (parental encouragement, objects in the infant’s everyday setting) play a greater role. Characteristics of the broader physical world also profoundly influence motor skills. For example, if children were reared in the moon’s reduced gravity, they would prefer jumping to walking or running!

When a skill is first acquired, infants must refine it. For example, one baby, just starting to crawl, often collapsed on her tummy and moved backward instead of forward. Soon she figured out how to propel herself forward by alternately pulling with her arms and pushing with her feet. As she experimented, she perfected the crawling motion (Adolph, Vereijken, & Denny, 1998). In mastering walking, toddlers practice six or more hours a day, traveling the length of 29 football fields! Gradually their small, unsteady steps change to a longer stride, their feet move closer together, their toes point to the front, and their legs become symmetrically coordinated (Adolph, Vereijken, & Shrout, 2003). As movements are repeated thousands of times, they promote new connections in the brain that govern motor patterns.

Look carefully at dynamic systems theory, and you will see why motor development cannot be genetically determined. Because it is motivated by exploration and the desire to master new tasks, heredity can map it out only at a general level. Instead of behaviors being hard-wired into the nervous system, they are softly assembled, and different paths to the same motor skill exist (Hopkins & Butterworth, 1997; Thelen & Smith, 1998).
actually moved away from the object! Consequently, hand reaching required far more practice than foot reaching. As these findings confirm, rather than following a strict, predetermined cephalocaudal pattern, the order in which motor skills develop depends on the anatomy of the body part being used, the surrounding environment, and the baby’s efforts.

- **CULTURAL VARIATIONS IN MOTOR DEVELOPMENT** - Cross-cultural research further illustrates how early movement opportunities and a stimulating environment contribute to motor development. Nearly a half-century ago, Wayne Dennis (1960) observed infants in Iranian orphanages who were deprived of the tantalizing surroundings that induce infants to acquire motor skills. The Iranian babies spent their days lying on their backs in cribs, without toys to play with. As a result, most did not move on their own until after 2 years of age. When they finally did move, the constant experience of lying on their backs led them to scoot in a sitting position rather than crawl on their hands and knees. Because babies who scoot come up against objects such as furniture with their feet, not their hands, they are far less likely to pull themselves to a standing position in preparation for walking. Indeed, by 3 to 4 years of age, only 15 percent of the Iranian orphans were walking.

Cultural variations in infant-rearing practices affect motor development. Ask this question of several parents you know: Should sitting, crawling, and walking be deliberately encouraged? Answers vary widely from culture to culture. Japanese mothers and mothers from rural India, for example, believe that such efforts are unnecessary. They say that children “just learn” (Seymour, 1999). Among the Zinacanteco Indians of southern Mexico, rapid motor progress is actively discouraged. Babies who walk before they know enough to keep away from cooking fires and weaving looms are viewed as dangerous to themselves and disruptive to others (Greenfield, 1992).

In contrast, among the Kipsigis of Kenya and the West Indians of Jamaica, babies hold their heads up, sit alone, and walk considerably earlier than North American infants. Kipsigi parents deliberately teach these motor skills. In the first few months, babies are seated in holes dug in the ground, and rolled blankets are used to keep them upright. Walking is promoted by frequently bouncing babies on their feet (Super, 1981). As Figure 4.9 shows, West Indian mothers use a highly stimulating, formal handling routine. They believe that exercise helps
infants grow strong, healthy, and physically attractive (Hopkins & Westra, 1988). From the evidence we have discussed so far, we must conclude that early motor development results from complex transactions between nature and nurture. As dynamic systems theory suggests, heredity establishes the broad outlines of change. But the precise sequence and rate of progress result from an ongoing dialogue between the brain, the body, and the physical and social environment.

**Fine Motor Development: Reaching and Grasping**

Of all motor skills, reaching may play the greatest role in infant cognitive development because it opens up a whole new way of exploring the environment (Bushnell & Boudreau, 1993). By grasping things, turning them over, and seeing what happens when they are released, infants learn a great deal about the sights, sounds, and feel of objects.

The development of reaching and grasping, illustrated in Figure 4.10, provides an excellent example of how motor skills start out as gross, diffuse activity and move toward mastery of fine movements. Newborns make well-aimed but poorly coordinated swipes or swings, called **pre-reaching**, toward an object dangled in front of them. Because they cannot control their arms and hands, they seldom contact the object (von Hofsten, 1982). Nevertheless, newborns try hard to bring their hand within the visual field and seem to reach to attain a goal: touching things (van der Meer, van der Weel, & Lee, 1995; von Hofsten, 2004). Like newborn reflexes, prereaching drops out—around 7 weeks of age. Yet these early behaviors suggest that babies are biologically prepared to coordinate hand with eye in the act of exploring (Thelen, 2001).

**DEVELOPMENT OF REACHING AND GRASPING**

At about 3 months, as infants develop the necessary eye-gaze and head and shoulder postural control, reaching reappears and improves in accuracy (Bertenthal & von Hofsten, 1998; Spencer et al., 2000). By 4 months, infants reach for a glowing object in the dark. And at 5 to 6 months, they reach for an object they can no longer see (one that has been darkened during the reach by switching off the lights)—a skill that improves over the next few months (Clifton et al., 1993, 1994; McCarty & Ashmead, 1999). These findings indicate that reaching does not require babies to use vision to guide their arms and hands. Instead, reaching is largely controlled by **proprioception**, our sense of movement and location in space, arising from stimuli within the body. When vision is freed from the basic act of reaching, it can focus on more complex adjustments, such as fine-tuning actions to fit the distance and shape of objects.

Reaching improves as depth perception advances and as infants gain greater control of body posture and arm and hand movements. Four-month-olds aim their reaches ahead of a moving object so they can catch it (von Hofsten, 1993). Around 5 months, babies reduce their efforts when an object is moved beyond their reach (Robin, Berthier, & Clifton, 1996). By 7

![Figure 4.10: Some milestones of voluntary reaching](photos-left-middle-left-middle-right-right.jpg)
months, their arms become more independent: They reach for objects with one arm, rather than extending both (Fagard & Pezé, 1997). During the next few months, infants become better at reaching for moving objects—ones that spin, change direction, or move closer or farther away (Wentworth, Benson, & Haith, 2000).

Individual differences in movement styles affect how reaching is perfected (Thelen, Corbetta, & Spencer, 1996). Babies with large, forceful arm movements must make them less vigorous to reach for a toy successfully. Those with quiet, gentle actions must use more muscle power to lift and extend their arms (Thelen et al., 1993). Each infant builds the act of reaching uniquely by exploring the match between current movements and those demanded by the task.

Once infants can reach, they start to modify their grasp. When the grasp reflex of the newborn period weakens at 3 to 4 months, it is replaced by the ulnar grasp, a clumsy motion in which the fingers close against the palm. Still, even 3-month-olds readily adjust their grasp to the size and shape of an object—a capacity that improves over the first year (Newman, Atkinson, & Braddick, 2001). Around 4 to 5 months, when infants begin to sit up, they no longer need their arms to maintain body balance. This frees both hands to explore objects. Babies of this age can hold an object in one hand while the other scans it with the tips of the fingers, and they frequently transfer objects from hand to hand (Rochat & Goubet, 1995). By the end of the first year, infants use the thumb and index finger opposingly in a well-coordinated pincer grasp. After that, the ability to manipulate objects greatly expands. The 1-year-old can pick up raisins and blades of grass, turn knobs, and open and close small boxes.

Between 8 and 11 months, reaching and grasping are well practiced. As a result, attention is freed from the motor skill to events that occur before and after obtaining the object. For example, 10-month-olds easily adjust their reach to anticipate their next action. They reach for a ball faster when they intend to throw it than when they intend to drop it carefully through a narrow tube (Claxton, Keen, & McCarty, 2003). Around this time, too, infants begin to solve simple problems that involve reaching, such as searching for and finding a hidden toy.

**EARLY EXPERIENCE AND REACHING**

Like other motor milestones, early experience affects reaching. In a well-known study, institutionalized infants given a moderate amount of visual stimulation—at first, simple designs; later, a mobile hung over their cribs—reached for objects 6 weeks earlier than infants given nothing to look at. A third group given massive stimulation—patterned crib bumpers and mobiles at an early age—also reached sooner than the unstimulated babies. But this heavy enrichment took its toll. These infants looked away and cried a great deal, and they were not as advanced in reaching as the moderately stimulated group (White & Held, 1966). These findings remind us that more stimulation is not necessarily better. Trying to push infants beyond their current readiness to handle stimulation can undermine the development of important motor skills. We will return to this theme at the end of this chapter, and in Chapter 5, where we consider brain development.

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**Ask Yourself**

**REVIEW** Cite evidence that motor development is not genetically programmed but rather is a joint product of biological, psychological, and environmental factors.

**APPLY** Roseanne hung mobiles and pictures above her newborn baby’s crib, hoping that this would stimulate her infant’s motor development. Is Roseanne doing the right thing? Why or why not?

**CONNECT** Provide several examples of how motor development influences infants’ social experiences. How do social experiences, in turn, influence motor development?

**REFLECT** Do you favor early training of infants in motor skills, such as crawling, standing, walking, and stair climbing? Why or why not?
Think back to White and Held’s study, described at the end of the previous section. It illustrates the close link between perception and action in discovering new skills. To reach for objects, maintain balance, or move across various surfaces, infants must continually coordinate their motor behavior with perceptual information. Acting and perceiving are not separate aspects of experience. Instead, motor activity provides infants with a vital means for exploring and learning about the world, and improved perception brings about more effective motor activity. The union of perceptual and motor information is basic to our nervous systems, and each domain supports development of the other (Bertenthal & Clifton, 1998; von Hofsten, 2004).

What can young infants perceive with their senses, and how does perception change with age? Researchers have sought answers to these questions for two reasons. First, studies of infant perception reveal in what ways babies are biologically prepared to perceive their world, and how brain development and experience expand their capacities. Second, infant perception is of interest because it sheds light on other aspects of development. For example, because touch, vision, and hearing permit us to interact with others, they are basic to emotional and social development. Through hearing, language is learned. And because knowledge of the world is first gathered through the senses, perception provides the foundation for cognitive development.

Studying infant perception is especially challenging because babies cannot describe their experiences. Fortunately, investigators can make use of a variety of nonverbal responses that vary with stimulation, such as looking, sucking, head turning, facial expressions, and reaching. As noted earlier, researchers also rely on operant conditioning and habituation to find out whether infants can make certain discriminations. And psychophysiological measures, such as stimulus-induced changes in respiration, heart rate, and EEG brain waves (event-related potentials, or ERPs), are sometimes used. We will see examples of these methods as we explore the baby’s sensitivity to touch, taste, smell, sound, and visual stimulation.

**Touch**

Touch is a fundamental means of interaction between parents and babies. Within the first few days, mothers can recognize their own newborn by stroking the infant’s cheek or hand (Kaitz et al., 1993). Touch helps stimulate early physical growth (see Chapter 3), and it is vital for emotional development. Therefore, it is not surprising that sensitivity to touch is well developed at birth. The reflexes listed in Table 4.1 on page 126 reveal that the newborn baby responds to touch, especially around the mouth, on the palms, and on the soles of the feet. During the prenatal period, these areas, along with the genitals, are the first to become sensitive to touch (Humphrey, 1978).

At birth, infants are quite sensitive to pain. If male newborns are circumcised, anesthesia is sometimes not used because of the risks associated with giving pain-relieving drugs to a very young infant. Babies often respond to pain with a high-pitched, stressful cry and a dramatic rise in heart rate, blood pressure, pupil dilation, and muscle tension (Jorgensen, 1999; Warnock & Sandrin, 2004). Recent research establishing the safety of certain local anesthetics for newborns promises to ease the pain of these procedures. Offering a nipple that delivers a sugar solution is also helpful; it quickly reduces crying and discomfort in young babies, preterm and full-term alike. And combining the sweet liquid with gentle holding by the parent lessens pain even more. Research on infant mammals indicates that physical touch releases endorphins—painkilling chemicals in the brain (Gormally et al., 2001; Nelson & Panksepp, 1998). Allowing a baby to endure severe pain overwhelms the nervous system with stress hormones, which can disrupt the child’s developing capacity to handle common, everyday stressors. The result is heightened pain sensitivity, sleep disturbances, feeding problems, and difficulty calming down when upset (Mitchell & Boss, 2002).

Touching that is pleasurable enhances babies’ responsiveness to the environment. An adult’s soft caresses induce infants to smile and become more attentive to the adult’s face (Stack & Muir, 1992). And
even newborns use touch to investigate their world. They habituate to an object placed in their palms (by reducing their holding) and recover to a novel object, indicating that they can use touch to distinguish object shapes (Sterri, Lhote, & Dutilleul, 2000). As reaching develops, babies frequently mouth novel objects, running their lips and tongue over the surface, after which they remove the object to look at it. Exploratory mouthing peaks in the middle of the first year as hand–mouth contact becomes more accurate (Lew & Butterworth, 1997). Then it declines in favor of more elaborate touching with the hands, in which infants turn, poke, and feel the surface of things while looking at them intently (Ruff et al., 1992).

**Taste and Smell**

At birth, facial expressions reveal that babies can distinguish several basic tastes. Like adults, they relax their facial muscles in response to sweetness, purse their lips when the taste is sour, and show a distinct archlike mouth opening when it is bitter (Steiner, 1979; Steiner et al., 2001). These reactions are important for survival. The food that best supports the infant’s early growth is the sweet-tasting milk of the mother’s breast. In contrast, many toxic substances are bitter tasting. Not until age 4 months do babies prefer a salty taste to plain water, a change that may prepare them to accept solid foods (Mennella & Beauchamp, 1998).

Nevertheless, newborns can readily learn to like a taste that at first evoked either a neutral or a negative response. For example, babies allergic to cow’s-milk formula who are given a soy or other vegetable-based substitute (typically very strong and bitter-tasting) soon prefer it to their mother’s breast spontaneously latch on to a nipple and begin sucking within an hour. If one breast is washed to remove its natural scent, most newborns grasp the unwashed breast, indicating that they are guided by smell (Varendi & Porter, 2001). At 4 days of age, breastfed babies prefer the smell of their own mother’s breast to that of an unfamiliar lactating mother (Cernoch & Porter, 1985). Bottle-fed babies orient to the smell of any lactating woman over the smells of formula or a nonlactating woman.

In many mammals, the sense of smell plays an important role in protecting the young from predators by helping mothers and babies identify each other. Although smell is less well developed in humans, traces of its survival value remain. Newborns given a choice between the smell of their own mother’s amniotic fluid and that of another mother spend more time oriented toward the familiar fluid (Marlier, Schaal, & Soussignan, 2000). The mothers of some babies had regularly consumed anise-flavored foods and drinks during the last 2 weeks of pregnancy; the other mothers had never consumed anise. On the day of birth, the two groups of infants responded similarly to a control odor (paraffin oil). When presented with the anise odor, babies of the anise-consuming mothers spent more time mouthing and turning toward the odor. In contrast, infants of non-anise-consuming mothers were far more likely to turn away and display negative facial expressions (see Figure 4.11). These responses were still apparent 4 days later, even though all mothers had refrained from consuming anise during this time.

In many mammals, the sense of smell plays an important role in protecting the young from predators by helping mothers and babies identify each other. Although smell is less well developed in humans, traces of its survival value remain. Newborns given a choice between the smell of their own mother’s amniotic fluid and that of another mother spend more time oriented toward the familiar fluid (Marlier, Schaal, & Soussignan, 1998). The smell of the mother’s amniotic fluid is comforting; babies exposed to it cry less than babies who are not (Varendi et al., 1998).

Immediately after birth, infants placed face down between their mother’s breasts spontaneously latch on to a nipple and begin sucking within an hour. If one breast is washed to remove its natural scent, most newborns grasp the unwashed breast, indicating that they are guided by smell (Varendi & Porter, 2001). At 4 days of age, breastfed babies prefer the smell of their own mother’s breast to that of an unfamiliar lactating mother (Cernoch & Porter, 1985). Bottle-fed babies orient to the smell of any lactating woman over the smells of formula or a nonlactating woman.
Newborn infants’ dual attraction to the odors of their mother and of the lactating breast helps them locate an appropriate food source and, in the process, begin to distinguish their caregiver from other people.

**Balance**

To take in and make sense of their surroundings, infants must be able to balance the body, adjusting their movements so they remain in a steady position relative to the surface on which they are sitting or standing. Making these postural changes is so important that three sources of sensory information signal a need to adapt body position: (1) **proprioceptive stimulation**, arising from sensations in the skin, joints, and muscles; (2) **vestibular stimulation**, arising from the semicircular canals of the inner ear; and (3) **optical-flow stimulation**, arising from movements in the visual field.

Research focuses largely on **optical flow**—visually detected movements in the surrounding environment—because it can be manipulated easily. Consider how you use optical-flow information. You sense that you are in motion when the entire visual field moves, and you make postural adjustments in accord with its direction and speed. For example, imagine yourself standing on a train pulling out of the station. Scenery flowing past you signals that you are moving. Your perceived direction (forward) is opposite the direction of optical flow, so you compensate by swaying backward to remain upright.

Even newborns adapt their head movements to optical flow (Jouen & Lepecq, 1989). As motor control improves, postural adjustments become more precise. In a series of studies, researchers placed 5- to 13-month-olds in a seat with pressure-sensitive receptors in the “moving room” shown in Figure 4.12. When the front and side walls of the room oscillated forward and backward, all infants displayed appropriate body movements. Between 5 and 9 months, as infants perfected sitting without support, their back-and-forth sway became more finely tuned to the optical-flow changes produced by oscillating walls of the moving room (Bertenthal, Rose, & Bai, 1997; Rose & Bertenthal, 1995).

Clearly, newborn babies have a sense of balance that they refine with motor control and experience. Like those of adults, infants’ postural adjustments to self-movement take place unconsciously, freeing their attention for exploration (Bertenthal & Clifton, 1998). But to support actions effectively, many postural adjustments must occur in advance of behavior. By the end of the first year, infants anticipate loss of balance. Researchers had 10- to 17-month-olds open a cabinet drawer to retrieve toys and then doubled the drawer’s resistance against their pull (Witherington et al., 2002). Between 13 and 16 months, when walking improves, babies increasingly tensed their arm and abdominal muscles prior to opening the drawer, thereby preventing a fall when they let go. Experience with walking may motivate toddlers to make these adjustments. As they repeatedly tumble over, perhaps they realize the need for preventive action.
Hearing

Newborn infants can hear a wide variety of sounds, although their sensitivity improves greatly over the first few months (Tharpe & Ashmead, 2001). At birth, infants prefer complex sounds, such as noises and voices, to pure tones. And babies only a few days old can tell the difference between a few sound patterns—a series of tones arranged in ascending versus descending order; utterances with two versus three syllables; the stress patterns of words, such as ma-ma versus ma-ma; and happy-sounding speech as opposed to speech with negative or neutral emotional qualities (Mastropieri & Turkewitz, 1999; Sansavini, Bertoncini, & Giovanelli, 1997; Trehub, 2001).

Over the first year, infants organize sounds into increasingly elaborate patterns. Between 4 and 7 months, they have a sense of musical phrasing. They prefer Mozart minuets with pauses between phrases to those with awkward breaks (Krumhansl & Jusczyk, 1990). At the end of the first year, infants recognize the same melody when it is played in different keys. And when the tone sequence is changed only slightly, they can tell that the melody is no longer the same (Trehub, 2001).

Responsiveness to sound provides support for the young baby’s exploration of the environment. Infants as young as 3 days old turn their eyes and head in the general direction of a sound. The ability to identify the precise location of a sound improves greatly over the first 6 months and shows further gains into the second year (Litovsky & Ashmead, 1997).

Young infants listen longer to human speech than structurally similar nonspeech sounds (Vouloumanos & Werker, 2004). And they can detect the sounds of any human language. Newborns make fine-grained distinctions between many speech sounds—“ba” and “ga,” “ma” and “na,” and the short vowel sounds “a” and “i,” to name just a few. For example, when given a nipple that turns on the “ba” sound, babies suck vigorously and then habituate. When the sound switches to “ga,” sucking recovers, indicating that infants detect this subtle difference. Using this method, researchers have found only a few speech sounds that newborns cannot discriminate. Their ability to perceive sounds not found in their own language is more precise than an adult’s (Aldridge, Stillman, & Bower, 2001; Jusczyk, 1995).

Listen carefully to yourself the next time you talk to a young baby. You will probably speak in ways that highlight important parts of the speech stream—use a slow, clear, high-pitched, expressive voice with a rising tone at the end of speech segments, and pause before continuing. Adults probably communicate this way because they notice that infants are more attentive when they do so. Indeed, newborns prefer human speech with these characteristics (Aslin, Jusczyk, & Pisoni, 1998). In addition, newborns will suck more on a nipple to hear a recording of their mother’s voice than that of an unfamiliar woman, and to hear their native language as opposed to a foreign language (Moon, Cooper, & Fifer, 1993; Spence & DeCasper, 1987). These preferences may have developed from hearing the muffled sounds of the mother’s voice before birth.

Over the first year, infants learn much about the organization of sounds in their native language. As they listen to the talk of people around them, they learn to focus on meaningful sound variations. ERP brain-wave recordings reveal that around 5 months, they become sensitive to syllable stress patterns in their own language (Weber et al., 2004). Between 6 and 8 months, they start to “screen out” sounds not used in their native tongue (Anderson, Morgan, & White, 2003; Polka & Werker, 1994). Soon after, they focus on larger speech units: They recognize familiar words in spoken passages, listen longer to speech with clear clause and phrase boundaries, and begin to divide the speech stream into wordlike units (Jusczyk, 2002; Jusczyk & Hohne, 1997; Soderstrom et al., 2003).

How do infants make such rapid progress in perceiving the structure of language? Research shows that babies are impressive statistical analyzers of the speech stream. In one set of studies, researchers had 8- and 9-month-olds listen to a continuous sequence of nonsense syllables. Then they gave the babies brief, new syllable sequences; some conformed to the syllable patterns in the original sequence and some did not. The babies quickly inferred syllable structure: They preferred to listen to new speech that preserved the original syllable patterns. In other words, they listened for statistical regularities, discriminating syllables that often occur together (indicating that they belong to the same word) from syllables that seldom occur together (signaling a word boundary). To cite an English example, consider the word sequence *pretty#baby*. After listening to the speech stream for just 1 minute (about 60 words), babies can distinguish a word-internal syllable pair...
Mothers often name objects—for example, saying “doggie”—while moving the toy and, sometimes, having the toy touch the infant. This multisensory stimulation helps infants associate words with objects.

In a study using nonsense words, 7-month-olds discriminated the ABA structure of “ga ti ga” and “li na li” from the ABB structure of “wo fe fe” and “ta la la” (Marcus et al., 1999). The infants seemed to detect simple word-order rules—a capacity that may help them figure out the basic grammar of their language.

Clearly, babies have a powerful ability to extract regularities from continuous, complex verbal stimulation. Some researchers believe that infants are innately equipped with a general learning mechanism for detecting structure in the environment, which they also apply to visual stimulation (Kirkham, Slemmer, & Johnson, 2002). Indeed, because communication is often multisensory (simultaneously verbal, visual, and tactile), infants receive much support from other senses in analyzing speech. Perhaps you have observed mothers name objects while demonstrating for their babies—for example, saying “doll” while moving a doll and, sometimes, having the doll touch the infant. Research confirms that when mothers speak to 5- to 8-month-olds, they provide a great deal of temporal synchrony between words, object motions, and touch (Gogate, Bahrick, & Watson, 2000). In doing so, they create a supportive learning environment: In two studies, 7-month-olds remembered associations between sounds and objects only when they heard the sound and saw the object move at the same time (Gogate & Bahrick, 1998, 2001).

Finally, infants’ special responsiveness to speech encourages parents to talk to their baby. As they do so, both readiness for language and the emotional bond between caregiver and child are strengthened. At first, infants depend on the union of auditory and visual stimuli to pick up emotional information. Three- and 4-month-olds can distinguish happy- from sad-sounding speech, but only while looking at people’s faces. Later, babies can discriminate positive from negative emotion in each sensory modality, first in voices and then in faces (Walker-Andrews, 1997).

Before we turn to visual development, consult the Milestones table on the following page for a summary of the perceptual capacities we have just considered.

**Vision**

For active exploration of the environment, humans depend on vision more than any other sense. Yet vision is the least mature of the newborn baby’s senses. Visual structures in the eye and the brain continue to develop after birth. For example, cells in the retina, the membrane lining the inside of the eye that captures light and transforms it into messages that are sent to the brain, are not as mature or densely packed at birth as they will be several months later. Likewise, the optic nerve and other pathways that relay these messages, and the visual centers in the brain that receive them, will not be adultlike for several years. Furthermore, the muscles of the lens, which permit us to adjust our focus to varying distances, are weak (Atkinson, 2000).

Because visual structures are immature, newborn babies cannot focus their eyes well, and their visual acuity, or fineness of discrimination, is limited. At birth, infants perceive objects at a distance of 20 feet about as clearly as adults do at 600 feet (Slater, 2001). In addition, unlike adults (who see nearby objects most clearly), newborn babies see unclearly across a wide range of distances (Banks, 1980; Hainline, 1998). As a result, images such as the parent’s face, even from close up, look like the blurry image in Figure 4.13. And despite their prefer-
ence for colored over gray stimuli, newborn babies are not yet good at discriminating colors. But by 2 months, infants can discriminate colors across the entire spectrum (Teller, 1998).

Although they cannot yet see well, newborns actively explore their environment by scanning it for interesting sights and tracking moving objects. However, their eye movements are slow and inaccurate. The visual system develops rapidly over the first few months. Around 2 months, infants can focus on objects about as well as adults can. Visual acuity increases steadily, reaching a near-adult level of about 20/20 by 6 months (Slater, 2001). Scanning and tracking improve over the first half-year as infants see more clearly and eye movements come under voluntary control (von Hofsten & Rosander, 1998). In addition, as young infants build an organized perceptual world, they scan more thoroughly and systematically, strategically picking up important information and anticipating with their eye movements what they expect to happen next in a series of events (Haith, 1994; Johnson, Slemmer, & Amso, 2004). Consequently, scanning enhances perception, and perception enhances scanning, in bidirectional fashion.

As infants explore the visual field more adeptly, they figure out the characteristics of objects and how they are arranged in space. We can best understand how they do so by examining the development of three aspects of vision: depth, pattern, and object perception.

**DEPTH PERCEPTION** Depth perception is the ability to judge the distance of objects from one another and from ourselves. It is important for understanding the layout of the environment and for guiding motor activity. To reach for objects, babies must have some sense of...
depth. Later, when infants crawl, depth perception helps prevent them from bumping into furniture and falling down stairs.

Figure 4.14 shows the well-known **visual cliff**, designed by Eleanor Gibson and Richard Walk (1960) and used in the earliest studies of depth perception. It consists of a Plexiglas-covered table with a platform at the center, a “shallow” side with a checkerboard pattern just under the glass, and a “deep” side with a checkerboard several feet below the glass. The researchers found that crawling babies readily crossed the shallow side, but most reacted with fear to the deep side. They concluded that around the time that infants crawl, most distinguish deep from shallow surfaces and avoid drop-offs.

The research of Gibson and Walk shows that crawling and avoidance of drop-offs are linked, but it does not tell us how they are related or when depth perception first appears. To better understand the development of depth perception, recent research has looked at babies’ ability to detect specific depth cues, using methods that do not require that they crawl.

### Emergence of Depth Perception

How do we know when an object is near rather than far away? To find out, try these exercises: Pick up a small object (such as your cup) and move it toward your face, then away. Did its image grow larger as it approached and smaller as it receded? Next time you take a car or bike ride, notice that nearby objects move past your field of vision more quickly than those far away.

**Kinetic depth cues**, created by movements of the body or of objects in the environment, are the first to which infants are sensitive. Babies 3 to 4 weeks old blink their eyes defensively when an object moves toward their face as if it is going to hit (Nánez & Yonas, 1994). As they are carried about and as people and things turn and move before their eyes, infants learn more about depth. For example, by the time they are 3 months old, motion has helped them figure out that objects are not flat but three-dimensional (Arterberry, Craton, & Yonas, 1993).

**Binocular depth cues** arise because our two eyes have slightly different views of the visual field. In a process called **stereopsis**, the brain blends these two images, resulting in perception of depth. To study infants’ sensitivity to binocular cues, researchers project two overlapping images before the baby, who wears special goggles to ensure that each eye receives one of the images. If babies use binocular cues, they will perceive and visually track an organized, three-dimensional form rather than seeing random dots. Results reveal that binocular sensitivity emerges between 2 and 3 months and improves rapidly over the first year (Birch, 1993; Brown & Miracle, 2003). Infants soon make use of binocular cues in their reaching, adjusting arm and hand movements to match the distance of objects.

Last to develop are **pictorial depth cues**—the ones artists use to make a painting look three-dimensional. Examples include receding lines that create the illusion of perspective, changes in texture (nearby textures are more detailed than faraway ones), and overlapping objects (an object partially hidden by another object is perceived to be more distant). Studies in which researchers observe whether babies reach toward the closer-appearing parts of images containing pictorial cues reveal that 7-month-olds are sensitive to these cues, although 5-month-olds are not (Sen, Yonas, & Knill, 2001; Yonas et al., 1986).

Why does perception of depth cues emerge in the order just described? Researchers speculate that motor development is involved. For example, control of the head during the early weeks of life may help babies notice motion and binocular cues. And around 5 to 6 months, the ability to turn, poke, and feel the surface of objects may promote perception of pictorial cues as infants pick up information about size, texture, and shape (Bushnell & Boudreau, 1993). Indeed, as we will see next, research shows that one aspect of motor progress—indeed, movement—plays a vital role in refinement of depth perception.

### Crawling and Depth Perception

A mother I know described her newly crawling 9-month-old as a “fearless daredevil.” “If I put April down in the middle of our bed, she crawls right over the edge,” the mother exclaimed. “The same thing’s happened by the stairs.”

Will April become more wary of the side of the bed and the staircase as she becomes a more experienced crawler? Research suggests that she will. Infants with more crawling experience
(regardless of when they start to crawl) are far more likely to refuse to cross the deep side of the visual cliff (Bertenthal, Campos, & Barrett, 1984; Campos, 2000).

What do infants learn from crawling that promotes this sensitivity to depth information? Research suggests that from extensive everyday experience, babies gradually figure out how to use depth cues to detect the danger of falling. But because the loss of postural control that leads to falling differs greatly for each body position, babies must undergo this learning separately for each posture. In one study, 9-month-olds, who were experienced sitters but novice crawlers, were placed on the edge of a shallow drop-off that could be widened (Adolph, 2000). While in the familiar sitting position, infants avoided leaning out for an attractive toy at distances likely to result in falling. But in the unfamiliar crawling posture, they headed over the edge, even when the distance was extremely wide! As infants discover how to avoid falling in diverse postures and situations, their understanding of depth expands.

Crawling experience promotes other aspects of three-dimensional understanding. For example, seasoned crawlers are better than their inexperienced agemates at remembering object locations and finding hidden objects (Bai & Bertenthal, 1992; Campos et al., 2000). Why does crawling make such a difference? Compare your experience of the environment when you are driven from one place to another as opposed to walking or driving yourself. When you move on your own, you are much more aware of landmarks and routes of travel, and you take more careful note of what things look like from different points of view. The same is true for infants. In fact, crawling promotes a new level of brain organization, as indicated by more organized EEG brain-wave activity in the cerebral cortex. Perhaps crawling strengthens certain neural connections, especially those involved in vision and understanding of space (Bell & Fox, 1996). As the Biology and Environment box on page 156 reveals, the link between independent movement and spatial knowledge is also evident in a population with very different perceptual experience: infants with severe visual impairments.

**PATTERN PERCEPTION** • Even newborns prefer to look at patterned as opposed to plain stimuli—for example, a drawing of the human face or one with scrambled facial features rather than a black-and-white oval (Fantz, 1961). As infants get older, they prefer more complex patterns. For example, 3-week-olds look longest at black-and-white checkerboards with a few large squares, whereas 8- and 14-week-olds prefer those with many squares (Brennan, Ames, & Moore, 1966).

**Contrast Sensitivity.** A general principle, called contrast sensitivity, explains early pattern preferences (Banks & Ginsburg, 1985). Contrast refers to the difference in the amount of light between adjacent regions in a pattern. If babies are sensitive to (can detect) the contrast in two or more patterns, they prefer the one with more contrast. To understand this idea, look at the checkerboards in the top row of Figure 4.15. To us, the one with many small squares has more contrasting elements. Now look at the bottom row, which shows how these checkerboards appear to infants in the first few weeks of life. Because of their poor vision, very young babies cannot resolve the small features in more complex patterns, so they prefer to look at the large, bold...
Development of Infants with Severe Visual Impairments

Research on infants who can see little or nothing at all dramatically illustrates the interdependence of vision, motor exploration, social interaction, and understanding of the world. In a longitudinal study, infants with a visual acuity of 20/800 or worse—that is, they had only dim light perception or were blind—were followed through the preschool years. Compared to agemates with less severe visual impairments, they showed serious delays in all aspects of development. Motor and cognitive functioning suffered the most; with age, performance in both domains became increasingly distant from that of other children (Hatton et al., 1997).

What explains these profound developmental delays? Minimal or absent vision can alter the child’s experiences in at least two crucial, interrelated ways.

Impact on Motor Exploration and Spatial Understanding
Infants with severe visual impairments attain gross and fine motor milestones many months later than their sighted counterparts (Levtzion-Korach et al., 2000). For example, on average, blind infants do not reach for and manipulate objects until 12 months, crawl until 13 months, and walk until 19 months (compare these averages to the motor norms given in the Milestones table on page 143). Why is this so?

Infants with severe visual impairments must rely on sound to identify the whereabouts of objects. But sound does not function as a precise clue to object location until much later than vision—around the middle of the first year (Litovsky & Ashmead, 1997). And because infants who cannot see have difficulty engaging their caregivers, adults may not provide them with rich early exposure to sounding objects. As a result, the baby comes to understand relatively late that there is a world of tantalizing objects to explore.

Until “reaching on sound” is achieved, infants with severe visual impairments are not motivated to move independently. Because of their own uncertainty coupled with parents’ protectiveness and restraint to prevent injury, blind infants are typically tentative in their movements. These factors delay motor development further.

Motor and cognitive development are closely linked, especially for infants with little or no vision. These babies build on understanding of the location and arrangement of objects in space only after reaching and crawling (Bigelow, 1992). As these children get older, inability to imitate the motor actions of others presents additional challenges, contributing to declines in motor and cognitive progress relative to peers with better vision (Hatton et al., 1997).

Impact on the Caregiver-Infant Relationship
Infants who see poorly have great difficulty evoking stimulating caregiver interaction. They cannot make eye contact, imitate, or pick up nonverbal social cues. Their emotional expressions are muted; for example, their smile is fleeting and unpredictable. And because they cannot gaze in the same direction as a partner, they are greatly delayed in establishing a shared focus of attention on objects as the basis for play (Bigelow, 2003). Consequently, these infants may receive little adult attention and other stimulation vital for all aspects of development.

When a visually impaired child does not learn how to participate in social interaction during infancy, communication is compromised in early childhood. In an observational study of blind children enrolled in preschools with sighted agemates, the blind children seldom initiated contact with peers and teachers. When they did interact, they had trouble interpreting the meaning of others’ reactions and responding appropriately (Preisler, 1991, 1993).

Interventions
Parents, teachers, and caregivers can help infants with minimal vision overcome early developmental delays through stimulating, responsive interaction. Until a close emotional bond with an adult is forged, visually impaired babies cannot establish vital links with their environments.

Techniques that help infants become aware of their physical and social surroundings include heightened sensory input through combining sound and touch (holding, touching, or bringing the baby’s hands to the adult’s face while talking or singing), engaging in many repetitions, and consistently reinforcing the infant’s efforts to make contact. Manipulative play with objects that make sounds is also vital.

Finally, rich language stimulation can compensate for visual loss (Conti-Ramsden & Pérez-Pereira, 1999). It grants young children a ready means of finding out about objects, events, and behaviors they cannot see. Once language emerges, many children with limited or no vision show impressive rebounds. Some acquire a unique capacity for abstract thinking, and most master social and practical skills that permit them to lead productive, independent lives (Warren, 1994).
checkerboard. Around 2 months of age, when detection of fine-grained detail has improved considerably, infants become sensitive to the greater contrast in complex patterns and spend more time looking at them. Contrast sensitivity continues to improve during infancy and childhood (Gwiazda & Birch, 2001).

**Combining Pattern Elements.** In the early weeks of life, infants respond to the separate parts of a pattern. They stare at single, high-contrast features and have difficulty shifting their gaze away toward other interesting stimuli (Hunnius & Geuze, 2004a, 2004b). In exploring drawings of human faces, for example, 1-month-olds often limit themselves to the edges of the stimulus and focus on the hairline or chin. At 2 to 3 months, when contrast sensitivity improves and infants can better control their scanning, they thoroughly explore a pattern’s internal features, pausing briefly to look at each salient part (Bronson, 1994). (Recall from page 140 that some babies continue to focus on small features and, therefore, take in less information.)

At the same time, babies’ scanning varies with pattern characteristics. When exposed to dynamic stimuli, such as the mother’s nodding, smiling face, 6-week-olds fixate more on internal features (the mouth and eyes) than on edges. Furthermore, when stimuli are dynamic, development of scanning takes place over a longer period; thorough inspection of the entire stimulus emerges only after 4 months of age (Hunnius & Geuze, 2004b). Exploring complex moving patterns seems to be more demanding than exploring stationary patterns—a difference we must keep in mind as we examine research on pattern perception, which is based largely on static stimuli.

Once babies take in all aspects of a pattern, they integrate them into a unified whole. Around 4 months, they are so good at detecting organization in static patterns that they even perceive subjective boundaries that are not really present. For example, they perceive a square in the center of Figure 4.16a, just as you do (Ghim, 1990). Older infants carry this responsiveness to subjective form even further. For example, 9-month-olds show a special preference for an organized series of moving lights that resembles a human being walking, in that they look much longer at this display than at upside-down or scrambled versions (Bertenthal, 1993). At 12 months, infants detect objects represented by incomplete drawings, even when as much as two-thirds of the drawing is missing (see Figure 4.16b) (Rose, Jankowski, & Senior, 1997). By the end of the first year, a suggestive image is all that babies need to recognize a familiar form. As these findings reveal, infants’ increasing knowledge of objects and actions supports pattern perception. As we turn now to perception of the human face, we will see additional examples of this idea.

**FACE PERCEPTION** Infants’ tendency to search for structure in a patterned stimulus applies to face perception. Newborns prefer to look at simple, facelike stimuli with features arranged naturally (upright) rather than unnaturally (upside down or sideways) (see Figure 4.17a on page 158) (Mondloch et al., 1999). They also track a facelike pattern moving across their visual field farther than they track other stimuli (Johnson, 1999). And although their ability to distinguish real faces on the basis of inner features is limited, shortly after birth babies prefer photos of faces with eyes open and a direct gaze. Yet another amazing capacity is their tendency to look longer at faces judged by adults as attractive, compared with less
attractive ones—a preference that may be the origin of the widespread social bias favoring physically attractive people (Slater et al., 2000).

Some researchers claim that these behaviors reflect a built-in capacity to orient toward members of one’s own species, just as many newborn animals do (Johnson, 2001a; Slater & Quinn, 2001). In support of this view, the upright face preference occurs only when newborns view stimuli in the periphery of their visual field—an area of the retina governed by primitive brain centers (Cassia, Simion, & Umiltá, 2001). Others refute the claim that newborns have a special sensitivity to the facial pattern. Instead, they assert, newborns prefer any stimulus in which the most salient elements are arranged horizontally in the upper part of a pattern—like the “eyes” in Figure 4.17a. Indeed, newborns do prefer nonfacial patterns with these characteristics over other nonfacial arrangements (Simion et al., 2001; Turati, 2004). Possibly, however, a bias favoring the facial pattern promotes such preferences. Still other researchers argue that newborns are exposed to faces more often than to other stimuli—early experiences that could quickly “wire” the brain to detect faces and prefer attractive ones (Nelson, 2001).

Although newborns respond to a general, facelike structure, they cannot discriminate a complex, static image of the human face from other, equally complex configurations (see Figure 4.17b). Nevertheless, from repeated exposures to their mother’s face, they quickly learn to prefer her face to that of an unfamiliar woman, although they are sensitive only to its broad outlines, not its fine-grained features. Babies quickly apply their tendency to search for pattern to face perception. Around 2 months, when they can scan an entire stimulus and combine its elements into an organized whole, they recognize and prefer their mothers’ facial features (Bartrip, Morton, & de Schonen, 2001). And they prefer a drawing of the human face to other stimulus arrangements (Dannemiller & Stephens, 1988).

Around 3 months, infants make fine distinctions between the features of different faces. For example, they can tell the difference between the photos of two strangers, even when the faces are moderately similar (Morton, 1993). At 5 months—and strengthening over the second half of the first year—infants perceive emotional expressions as meaningful wholes. They treat positive faces (happy or surprised) as different from negative ones (sad or fearful), even when the expressions are demonstrated in varying ways by different models (Bornstein & Arterberry, 2003; Ludemann, 1991).

Extensive face-to-face interaction between infants and their caregivers undoubtedly contributes to the refinement of face perception. As we will see in Chapter 10, babies’ developing sensitivity to the human face supports their earliest social relationships and helps regulate exploration of the environment in adaptive ways.

OBJECT PERCEPTION

Research on pattern perception involves only two-dimensional stimuli, but our environment is made up of stable, three-dimensional objects. Do young infants perceive a world of independently existing objects—knowledge essential for distinguishing the self, other people, and things?

Size and Shape Constancy. As we move around the environment, the images objects cast on our retina constantly change in size and shape. To perceive objects as stable and unchanging, we must translate these varying retinal images into a single representation.

Size constancy—perception of an object’s size as stable, despite changes in the size of its retinal image—is evident in the first week of life. To test for it, researchers capitalized on the habituation response, using procedures described and illustrated in Figure 4.18. Perception of an object’s shape as stable, despite changes in the shape projected on the retina, is called shape constancy. Habituation research reveals that it, too, is present within the first week of life, long before babies can actively rotate objects with their hands and view them from different angles (Slater & Johnson, 1999).

In sum, both size and shape constancy appear to be built-in capacities that help babies detect a coherent world of objects. Yet they provide only a partial picture of young infants’ object perception.
Perception of Object Identity. As adults, we distinguish an object from its surroundings by looking for a regular shape and uniform texture and color. Very young infants, however, are not sensitive to these indicators of an object’s boundaries. At first, they rely heavily on motion and spatial arrangement to identify objects (Jusczyk et al., 1999; Spelke & Hermer, 1996). When two objects are touching and either move in unison or stand still, babies younger than 4 months cannot distinguish between them. Infants, as we saw earlier in this chapter, are fascinated by moving objects. As they observe objects’ motions, they pick up additional information about objects’ boundaries, such as shape, color, and texture.

For example, as Figure 4.19 reveals, around 2 months of age, babies first realize that a moving rod whose center is hidden behind a box is a complete rod rather than two rod pieces. Motion, a textured background, alignment of the top and bottom of the rod, and a small box (so most of the rod is visible) are necessary for young infants to infer object unity. They cannot do so without all these cues to heighten the distinction between objects in the display.
moving back and forth behind a screen (see Figure 4.20). Recovery to test events revealed that as long as the ball was out of view only briefly, 4-month-olds (but not younger infants) perceived the ball’s path as continuous rather than broken (Johnson et al., 2003). Once again, experience—in particular, watching objects move in and out of view—contributes to perception of a moving object’s path (Johnson, Amso, & Slemmer, 2003). Between 4 and 5 months, infants can monitor increasingly intricate paths of objects. As indicated by their anticipatory eye movements (looking ahead to where they expect an object to appear from behind a barrier), 5-month-olds even keep track of an object that travels on a curvilinear course at varying speeds (Rosander & von Hofsten, 2004).

Notice that perception of object unity in the rod-and-box task (Figure 4.19) is mastered before perception of the continuity of an object’s path of movement (Figure 4.20). Tracking a disappearing and reappearing object seems to pose extra challenges. We will revisit these attainments when we take up infants’ mastery of object permanence (understanding that an object still exists when hidden from view) in Chapter 6.

The Milestones table on the following page provides an overview of the vast changes that take place in visual perception during the first year. Up to this point, we have considered the sensory systems one by one. Now let’s examine their coordination.

### Intermodal Perception

We live in a world that provides us with a rich, continuous flux of intermodal stimulation—simultaneous input from more than one modality, or sensory system. In intermodal perception, we make sense of these running streams of light, sound, tactile, odor, and taste information by perceiving unitary objects and events. We know, for example, that the shape of an object is the same whether we see it or touch it, that lip movements are closely coordinated with the sound of a voice, that breaking a glass causes a sharp, crashing sound, and that the patter of footsteps signals the approach of a person. How do infants, who begin life with no prior knowledge to guide them, figure out which strands of sensory stimulation go together, and which do not?

Recall that in the first few days of life, babies turn in the general direction of a sound and reach for objects in a primitive way. These behaviors suggest that infants expect sight, sound, touch to go together. Research reveals that babies perceive input from different sensory systems in a unified way by detecting amodal sensory properties, information that is not specific to a single modality but that overlaps two or more sensory systems, such as rate, rhythm, duration, intensity, and (for vision and hearing) temporal synchrony. Consider the sight and sound

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*a Figure 4.20*

Testing infants’ ability to perceive an object’s path of movement. (a) Infants are habituated to a ball moving back and forth behind a screen. Next, they are shown two test displays in alternation: (b) a ball undergoing continuous back-and-forth motion, with its full trajectory visible, and (c) a ball undergoing discontinuous motion, out of and back into view just as in the habituation stimulus, but without moving back behind a visible screen. As long as the ball is out of sight only briefly in the habituation display, 4-month-olds typically recover to (look longer at) the discontinuous motion than the continuous motion. Their novelty preference suggests that they perceive the motion of the ball behind the screen in the first display as continuous.

of a bouncing ball or the face and voice of a speaking person. In each event, visual and auditory information are conveyed simultaneously and with the same rate, rhythm, duration, and intensity.

Early on, both animal and human babies are impressive perceivers of amodal properties (Lickliter & Bahrick, 2000). In one study, bobwhite quail embryos were exposed to a light flashing in synchrony with the rate and rhythm of a typical maternal call during the 24 hours before they hatched. After birth, the intermodally stimulated chicks developed a preference for the familiar call over a novel call four times faster than chicks exposed to only the call or the
Babies quickly learn associations between the sights, sounds, and feel of toys, as this 3-month-old is doing, assisted by her mother. Within the first half-year, infants master a remarkable range of intermodal relationships.

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Flashing light. Clearly, the embryos responded to amodal information, which influenced their later learning (Lickliter, Bahrick, & Honeycutt, 2002). Similarly, human newborns are highly sensitive to amodal properties in audiovisual stimulation. For example, after just one exposure, they quickly learn associations between the sights and sound of toys, such as a rhythmically jangling rattle (Morrongiello, Fenwick, & Chance, 1998).

Within the first half-year, infants master a remarkable range of intermodal relationships. For example, they match the motions of a wide array of objects with their appropriate sounds. In one such study, 3- and 4-month-olds watched two films side by side, one with two blocks banging and the other with two sponges being squashed together. At the same time, the sound track for only one of the films (either a sharp, banging noise or a soft, squishing noise) could be heard. Infants looked at the film that went with the sound track (Bahrick, 1983). In similar research, infants matched faces with voices on the basis of lip–voice synchrony, emotional expression, and even age and gender of the speaker (Bahrick, Netto, & Hernandez-Reif, 1998; Walker-Andrews, 1997). Furthermore, recall that 5- to 6-month olds will reach for an object in a room that has been darkened during their reach—a behavior that illustrates the union of sight and touch. They also will reach for a sounding object in the dark, displaying union of sound and touch (Clifton et al., 1994).

In addition to detecting amodal properties, babies gradually learn many intermodal associations that are arbitrary, such as the relation between a person’s face and the particular sound of his or her voice or between the appearance of an object and its verbal label. The detection of amodal relations precedes and seems to provide a basis for differentiation of these more specific intermodal matches (Bahrick, 2001).

Indeed, young infants’ intermodal sensitivity is crucial for perceptual development. In the early months, infants detect amodal properties only when exposed to intermodal stimulation. For example, 3-month-olds discriminated a change in the rhythm of a toy hammer tapping from an audiovisual display, but not from a purely auditory presentation (just hearing the tapping) or a purely visual presentation (just seeing the hammer move) (Bahrick, Flom, & Lickliter, 2003). Intermodal stimulation makes amodal properties (such as rhythm) stand out. As a result, inexperienced perceivers notice a meaningful unitary event (the hammer’s intricate tapping) and are not diverted to momentarily irrelevant aspects of the situation, such as the hammer’s color or orientation. In contrast, young infants notice changes in purely visual properties, such as color, orientation, and pattern, only when exposed to purely visual information (Bahrick, Lickliter, & Flom, 2004). With experience, perceptual capacities become more flexible. In the second half of the first year, infants can discriminate amodal properties in both intermodal and unimodal (sights or sounds alone) stimulation. But early on, when much input is unfamiliar and confusing, intermodal stimulation helps babies selectively attend to and make sense of their surroundings.

In addition to easing infants’ perception of the physical world, intermodal stimulation facilitates social and language processing, as evidence reviewed earlier in this chapter illustrates. Recall that an adult’s gentle touch induces infants to attend to her face (see page 148). And as infants gaze at an adult’s face, they initially require both vocal and visual input to distinguish positive from negative emotional expressions. Furthermore, in their earliest efforts to make sense of language, infants profit from temporal synchrony between a speech sound and the motion of an object (page 152).

In sum, intermodal perception is a fundamental ability that fosters all aspects of psychological development. In animals, the intermodal stimulation arising out of early social inter-
action—for example, the mother’s simultaneous touch, smell, vocalizations, and gestures—is vital for normal development of both intermodal and unimodal perceptual responsiveness (Lickliter & Bahrick, 2000). The same is likely to be true for human infants.

**Understanding Perceptual Development**

Now that we have reviewed the development of infant perceptual capacities, how can we put together this diverse array of amazing achievements? Widely accepted answers come from the work of Eleanor and James Gibson. According to the Gibsons’ differentiation theory, infants actively search for invariant features of the environment—those that remain stable—in a constantly changing perceptual world. For example, in pattern perception, at first babies are confronted with a confusing mass of stimulation. Very quickly, however, they search for features that stand out along the border of a stimulus and orient toward images that crudely represent a face. Soon they explore internal features and notice stable relationships between those features. As a result, they detect patterns, such as complex designs and faces. The development of intermodal perception also reflects this principle. Babies seek out invariant relationships—for example, amodal properties, such as rhythm—in concurrent sights and sounds. Gradually, they perceive more detailed intermodal associations. And, eventually, they can distinguish amodal properties in unimodal stimulation.

The Gibsons use the word differentiation (which means analyzing or breaking down) to describe their theory because, over time, the baby detects finer and finer invariant features among stimuli. In addition to pattern perception and intermodal perception, differentiation applies to depth and object perception. Recall how, in each, sensitivity to motion precedes detection of detailed stationary cues. So one way of understanding perceptual development is to think of it as a built-in tendency to search for order and consistency, a capacity that becomes increasingly finely tuned with age (Gibson, 1970; Gibson, 1979).

Acting on the environment is vital in perceptual differentiation. According to the Gibsons, perception is guided by discovery of affordances—the action possibilities that a situation offers an organism with certain motor capabilities (Gibson, 2000, 2003). By moving about and exploring the environment, babies figure out which objects can be grasped, squeezed, bounced, or stroked and whether a surface is safe to cross or presents the possibility of falling. Sensitivity to these affordances makes our actions future oriented and largely successful rather than reactive and blundering. Consequently, we spend far less time correcting ineffective actions than we otherwise would.

To illustrate, let’s consider how infants’ changing capabilities for independent movement affect their perception. When babies crawl, and again when they walk, they gradually realize that a steeply sloping surface affords the possibility of falling (see Figure 4.21). With added weeks of practicing each skill, they hesitate to crawl or walk down a risky incline. Experience in trying to keep their balance on various surfaces seems to make crawlers and walkers more aware of the consequences of their movements. Crawlers come to detect when surface slant places so
Early Deprivation and Enrichment: Is Infancy a Sensitive Period of Development?

Throughout this chapter, we have discussed how a variety of early experiences affect the development of motor and perceptual skills. In view of the findings already reported, it is not surprising that many investigations have found that stimulating physical surroundings and warm caregiving that is responsive to infants’ self-initiated efforts promote active exploration of the environment and earlier attainment of developmental milestones (see, for example, Belsky & Fearon, 2002; Bendersky & Lewis, 1994).

The powerful effect of early experience is dramatically apparent in infants who lack the rich, varied stimulation of normal homes. Babies reared in severely deprived family situations or in institutions remain substantially below average in physical and psychological development and display emotional and behavior problems throughout childhood (Johnson, 2000). These findings indicate that early experience has a profound impact, but they do not tell us whether infancy is a sensitive period. That is, if babies do not experience appropriate stimulation of their senses in the first year or two of life, can they ever fully recover? This question is controversial. Recall from Chapter 1 that some theorists argue that early experience leaves a lasting imprint on the child’s competence. Others believe that most developmental delays resulting from events in the first few years of life can be overcome.

The existence of sensitive periods has been amply demonstrated in studies of animals exposed to extreme forms of sensory deprivation. For example, rich and varied visual experiences must occur during a specific time for the visual centers of a kitten’s brain to develop...
normally. If a month-old kitten is deprived of light for as brief a time as 3 or 4 days, these areas of the brain degenerate. If the kitten is kept in the dark during the fourth week of life and beyond, the damage is severe and permanent (Crair, Gillespie, & Stryker, 1998). Furthermore, the general quality of the early environment affects overall brain growth. When animals reared from birth in physically and socially stimulating surroundings are compared with those reared in isolation, the brains of the stimulated animals are larger (Greenough & Black, 1992).

For ethical reasons, we cannot deliberately deprive some infants of normal rearing experiences and observe the impact on their brains and competencies. The best available test of whether infancy is a sensitive period comes from natural experiments, in which children were victims of deprived early environments but were later exposed to stimulating, sensitive care. If the sensitive period hypothesis is correct, then the effects of deprivation during infancy should persist, even when children are moved into enriched settings.

Research on children from Eastern European orphanages consistently shows that the earlier infants are removed from deprived rearing conditions, the greater their catch-up in development. In one study, Michael Rutter and his colleagues (1998, 2004; O’Connor et al., 2000) followed the progress of a large sample of children transferred between birth and 3 1/2 years from Romanian orphanages to adoptive families in Great Britain. On arrival, most were malnourished, prone to infection, and impaired in all domains of development. By the preschool years, catch-up in height and weight was dramatic. Although cognitive catch-up was also impressive, it was not as great for children adopted after 6 months of age. These adoptees were far more likely to display cognitive impairment and behavior problems at 6 years than were Romanian or British children adopted in the first 6 months of life. The longer infants were institutionalized, the more severe and persistent their deficits; those adopted after 2 years of age were profoundly affected (see Figure 4.22). Finally, even among babies who arrived in Great Britain adequately nourished, a major correlate of both time spent in the institution and poor cognitive functioning was below-average head size. These findings suggest that early lack of stimulation damaged the brain.

An investigation of Romanian babies adopted into Canada yielded findings consistent with the British study: Children who spent 2 or more years in institutions showed severe cognitive, emotional, and social deficits that were still apparent at age 9 (Ames & Chisholm, 2001; MacLean, 2003). In sum, exposing babies to deprived institutional care for 2 years seems to undermine permanently all aspects of their psychological development.

Figure 4.22

Relationship of age at adoption to incidence of cognitive impairment at age 6 years among British and Romanian adoptees. Children transferred from Romanian orphanages to British adoptive homes in the first 6 months of life fared as well as British early-adopted children, suggesting that they had fully recovered from extreme early deprivation. Romanian children adopted after 6 months of age showed an increasing incidence of cognitive impairment with time spent institutionalized. Those adopted after 2 years of age were profoundly affected; 30 percent scored below 80 on an intelligence test. (Adapted from Rutter et al., 2004.)
Among institutionalized infants, abnormal development in one domain often impedes progress in others. For example, adoptive parents of children from orphanages often report visual impairments. A frequent problem is strabismus (commonly known as “crossed eyes”), in which the eyes, because of muscle weakness, do not converge on the same point in space. Untreated infants, for whom strabismus persists longer than a few months, show abnormalities in the brain’s visual structures and permanent deficits in visual acuity, depth perception, tracking of moving objects, and perception of the spatial layout of the environment (Tychsen, 2001). Also, the bland, colorless rooms where orphanage infants spend their days, rarely touched or spoken to, lead to deficits in intermodal perception (Cermak & Daunhauer, 1997). Children who have trouble integrating information across modalities tend to be overwhelmed by stimulation, reacting to it with disorganized behavior or withdrawal. As a result, motor, cognitive, and social development suffers.

Unfortunately, many infants reared in underprivileged environments—whether homes or institutions—continue to be affected by disadvantaged conditions during their childhood years. As we will see in later chapters, interventions that break this pattern with warm, stimulating caregiver interaction and environmental enrichment have lasting cognitive and social benefits. One of the most important outcomes is that withdrawn, apathetic babies become active, alert beings with the capacity to evoke positive interactions from caregivers and to initiate stimulating play and exploration for themselves.

Finally, in addition to impoverished environments, ones that overwhelm children with expectations beyond their current capacities also undermine development. In recent years, expensive early learning centers have sprung up, in which infants are trained with letter and number flash cards, and slightly older toddlers are given a full curriculum of reading, math, science, art, gym, and more. There is no evidence that these programs yield smarter, better “superbabies” (Hirsh-Pasek & Golinkoff, 2003). Instead, trying to prime infants with stimulation for which they are not ready can cause them to withdraw, threatening their spontaneous interest and pleasure in learning and creating conditions much like those of stimulus deprivation! We will return to this theme when we take up brain development in Chapter 5.

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This child has spent her life in an orphanage in Tula, Russia, with little adult contact and little stimulation. The longer she remains in this barren environment, the more she will withdraw and wither and display permanent impairments in all domains of development.
nervous system abnormalities, which may contribute to sudden infant death syndrome (SIDS).

A crying baby stimulates strong feelings of discomfort in nearby adults. The intensity of the cry and the experiences that led up to it help parents identify what is wrong. Once feeding and diaper changing have been tried, lifting the baby to the shoulder and rocking or walking is the most effective soothing technique. According to ethological research, prompt parental responsiveness to infant crying results in a baby who cries less over time. A shrill, piercing cry is an indicator of central nervous system distress.

Why is neonatal behavioral assessment useful?
- The most widely used instrument for assessing the organized functioning of newborn infants is Brazelton’s Neonatal Behavioral Assessment Scale (NBAS). It has helped researchers understand individual and cultural differences in newborn behavior. Sometimes it is used to teach parents about their baby’s capacities—knowledge that can help parents interact more confidently and sensitively.

Describe infant learning capacities, the conditions under which they occur, and the unique value of each.
- Classical conditioning permits infants to recognize which events usually occur together in the everyday world. In this form of learning, a neutral stimulus is paired with an unconditioned stimulus (UCS) that produces a reflexive, or unconditioned, response (UCR). Once learning has occurred, the neutral stimulus, now called the conditioned stimulus (CS), by itself elicits a similar response, called the conditioned response (CR). Extinction occurs when the conditional stimulus is presented enough times without the unconditioned stimulus to result in a decline of the conditioned response. Young infants can be classically conditioned when the pairing of a UCS with a CS has survival value.

- Operant conditioning helps infants explore and control their surroundings. In addition to food, interesting sights and sounds serve as effective reinforcers, increasing the occurrence of a preceding behavior. Punishment involves removing a desirable stimulus or presenting an unpleasant one to decrease the occurrence of a response. With age, operant conditioning expands to include a wider range of stimuli and responses. The technique has yielded important information about infant memory—that retention of operant responses increases dramatically over the first year and a half.

- Habituation and recovery reveal that at birth, babies are attracted to novelty. With age, infants habituate and recover more quickly. Novelty preference (recovery to a novel stimulus) assesses infants’ recent memory, whereas familiarity preference (greater responsiveness to a familiar stimulus) assesses infants’ remote memory. Habituation research reveals that young infants are especially attracted to motion and that they remember the movements of objects and people for weeks to months. Speed of habituation and recovery in infancy are among the best early predictors of intelligence in childhood and adolescence.

- Newborn infants have a primitive ability to imitate the facial expressions and gestures of adults. Some researchers regard newborn imitation as little more than an automatic response to specific stimuli. Others believe that it is a flexible, voluntary capacity that contributes to self- and social awareness and the early parent–infant relationship.

Motor Development in Infancy
Describe the course of gross and fine motor development during the first 2 years, along with factors that influence it.
- Overall, motor development follows the cephalocaudal and proximodistal trends. But some dramatic exceptions exist; for example, infants reach with their feet before they reach with their hands. According to dynamic systems theory of motor development, new motor skills develop as existing skills combine into increasingly complex systems of action. Each new skill is a joint product of central nervous system development, movement possibilities of the body, the goal the child has in mind, and environmental supports for the skill.

- Movement opportunities and a stimulating environment profoundly affect motor development, as shown by research on infants raised in institutions. Cultural values and child-rearing customs also contribute to the emergence and refinement of motor skills.

- During the first year, infants gradually perfect their reaching and grasping. The poorly coordinated prereaching of the newborn period eventually drops out. As depth perception and control of body posture and the arms and hands improve, reaching and grasping become more flexible and accurate. Gradually, the clumsy ulnar grasp is transformed into a refined pincer grasp.

Perceptual Development in Infancy
Describe the newborn baby’s senses of touch, taste, smell, and hearing, noting changes during infancy.
- Newborns are highly sensitive to touch and pain. They have a preference for a sweet taste and certain sweet odors; a liking for the salty taste emerges later and probably supports acceptance of solid foods. The taste preferences of young infants can be easily modified. The mother’s diet during pregnancy, through its impact on the amniotic fluid, influences newborns’ odor preferences. Newborns orient toward the odor of their own mother’s amniotic fluid and the lactating breast—responses that help them identify their caregiver and locate an appropriate food source.

- As responsiveness to optical flow reveals, newborn babies have a sense of balance that is fundamental to everything they learn through exploration. Postural adjustments take place unconsciously and improve with experience and motor control. By the end of the first year, infants anticipate loss of balance, thereby preventing falls.

- Newborns can distinguish almost all speech sounds. They are especially responsive to slow, clear, high-pitched expressive voices, to their own mother’s voice, and to speech in their native language. Over the
first year, babies organize sounds into more complex patterns. By the middle of the first year, they become more sensitive to the sounds of their own language.

- Soon babies use their remarkable ability to statistically analyze the speech stream to detect meaningful speech units. They also attend to regularities in word sequences, detecting simple word-order rules. Multisensory communication—mothers’ tendency to label an object while demonstrating—supports infants’ language learning.

Describe the development of vision in infancy, placing special emphasis on depth, pattern, and object perception.

- Vision is the least mature of the newborn baby’s senses. As the eye and visual centers in the brain develop during the first few months, focusing ability, visual acuity, scanning, tracking, and color perception improve rapidly. And as infants build an organized perceptual world, they scan more thoroughly and systematically.

- Research on depth perception reveals that responsiveness to kinetic depth cues appears by the end of the first month, followed by sensitivity to binocular depth cues between 2 and 3 months. Perception of pictorial depth cues emerges last, around 7 months of age.

- Experience in crawling facilitates coordination of action with depth information, although babies must learn to avoid drop-offs, such as the deep side of the visual cliff, for each body posture. Crawling promotes other aspects of three-dimensional understanding and results in a new level of brain organization.

- Contrast sensitivity accounts for infants’ early pattern preferences. At first, babies stare at single, high-contrast features and often limit themselves to the edges of a static pattern. At 2 to 3 months, they explore a pattern’s internal features and combine its elements into a unified whole. In the second half of the first year, they discriminate increasingly complex, meaningful patterns. By 12 months, they extract meaningful patterns from very little information, such as an incomplete drawing with as much as two-thirds missing.

- Newborns prefer to look at and track simple, facelike stimuli. However, researchers disagree on whether they have an innate tendency to orient toward human faces. At 2 months, infants recognize and prefer their mothers’ facial features, and they prefer a drawing of the human face to other stimulus arrangements. By 3 months, infants make fine distinctions between the features of different faces; at 5 months, and strengthening over the second half of the first year, babies perceive emotional expressions as organized, meaningful wholes.

- At birth, size and shape constancy assist infants in building a coherent world of three-dimensional objects. Initially, infants depend on motion and spatial arrangement to identify objects. After 4 months, they rely increasingly on other features, such as distinct color, shape, and texture. At about this time, infants begin to register the continuous path of movement of an object that moves in and out of sight.

- Infants have a remarkable capacity to engage in intermodal perception. Newborn babies are highly sensitive to amodal sensory properties (such as rate, rhythm, duration, intensity, and temporary synchrony), which enable them to perceive input from different sensory systems in a unified way. Babies quickly master many intermodal associations, often after just one exposure to a new situation. Detection of amodal relations precedes and may provide a basis for detecting other intermodal matches.

- Intermodal stimulation helps young babies selectively attend to meaningful unitary events. It is a fundamental ability that fosters all aspects of psychological development, including perception of the physical world and social and language processing.

- According to differentiation theory, perceptual development is a matter of detecting increasingly fine-grained, invariant features in a constantly changing perceptual world. Perception is guided by discovery of affordances—the action possibilities a situation offers the individual.

Describe infants’ capacity for intermodal perception, and explain differentiation theory of perceptual development.

Early Deprivation and Enrichment: Is Infancy a Sensitive Period of Development?

Explain how research on early deprivation and enrichment sheds light on the question of whether infancy is a sensitive period of development.

- Natural experiments on children from Eastern European orphanages placed in adoptive families at various ages support the view that infancy is a sensitive period. The later children are removed from deprived rearing conditions, the less favorably they develop. When children spend the first 2 years or more in unstimulating institutions, they display severe and persistent impairments in all domains of development. Environments that overwhelm infants with stimulation beyond their current capacities also undermine development.
**Important Terms and Concepts**

affordances (p. 163)
amodal sensory properties (p. 160)
binocular depth cues (p. 154)
cephalocaudal trend (p. 143)
classical conditioning (p. 135)
conditioned response (CR) (p. 136)
conditioned stimulus (CS) (p. 136)
contrast sensitivity (p. 155)
differentiation theory (p. 163)
dynamic systems theory of motor development (p. 144)
extinction (p. 136)
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imitation (p. 141)
intermodal perception (p. 160)
invariant features (p. 163)
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Neonatal Behavioral Assessment Scale (NBAS) (p. 134)
non-rapid-eye-movement (NREM) sleep (p. 130)
operant conditioning (p. 136)
optical flow (p. 150)
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unconditioned response (UCR) (p. 135)
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