

LIFE SPAN MOTOR DEVELOPMENT

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Theoretical Perspectives in Motor Development

Changing Interpretations of Constraints



CHAPTER OBJECTIVES

This chapter

- describes the theories currently used to study motor development,
- illustrates how various theories explain changes in motor behavior, and
- describes the history of the field of motor development.



Motor Development in the Real World

The Birth of Your First Nephew

Imagine that you visit your older sister in a neighboring state just after she has had her first child. You see the infant as a newborn, just 1 week old. He does not really respond to you unless you place a bottle in his mouth or your finger in his hand. His movements include seemingly random flapping of the arms and legs—unless he is hungry, in which case he flails his limbs and cries! When you leave you think, “He seems pretty uncoordinated and weak.” After 9 months, you visit your sister and nephew again. What a change! He sits up on his own, reaches for toys, and has started to crawl. He can even stand when you hold him. He begins to coordinate his actions so that he can move purposefully. Now, let’s say you visit again, another 9 months later. Your nephew is no longer an infant but a full-fledged toddler. He can now walk—pretty quickly when he wants to—and has no problem with reaching and grasping. He is beginning to respond to language, particularly with the word *no*. He seems so very different from the newborn you met a mere 18 months before!

In this scenario it would be natural to wonder, “What happened during the past year and a half that resulted in these changes?” In other words, how can you (or anyone else) explain the changes seen across development? Given that there appear to be similarities in the development of different people (universality, described in chapter 1), how do we organize and understand these changes so that we can explain them and predict future development? Certain facts exist. How can we make sense of them? We must look at the different theoretical perspectives on motor development. Theories provide a systematic way to look at and explain developmental change.

Theories of motor development have roots in other disciplines, such as experimental and developmental psychology, embryology, and biology. Contemporary research in motor development often uses what is called an ecological perspective to describe, explain, and predict change. To interpret developmental “facts,” it is important to understand the different theoretical perspectives from which the supposed facts emerge. Knowing these theoretical perspectives will help us understand the explanations and form interpretations when several explanations conflict.

Maturational Perspective

KEY POINT

Maturationists believe that genetics and heredity are primarily responsible for motor development and that the environment has little effect.

In a nutshell, the maturational perspective explains developmental change as a function of maturational processes (in particular, through the central nervous system, or CNS) that control or dictate motor development. According to the assumptions of this theory, motor development is an internal or innate process driven by a biological or genetic time clock. The environment may speed or slow the process of change but it cannot change one’s biologically determined course.

The maturational perspective became popular during the 1930s, led by Arnold Gesell (Gesell, 1928, 1954; Salkind, 1981). Gesell believed that the biological and evolutionary history of humans determined their orderly and invariable sequence of development (i.e., each stage of development corresponds with a stage of evolution). The rate at which people pass through that developmental sequence, however, can differ from one individual to another. Gesell explained maturation as a process controlled by internal (genetic) factors rather than external (environmental) factors. He believed that environmental factors would affect motor development only temporarily because hereditary factors were ultimately in control of development.

Using identical twins as subjects, Gesell and his associates introduced the co-twin control strategy to developmental research (figure 2.1). What better way to test the effects of environment and heredity than to look at twins? In this strategy, one twin receives a specific training (the experimental treatment) while the other receives no special training (the control treatment). Thus, the control develops naturally, as any child would without special training. In this manner, Gesell examined the effects of the environment on development.

After a certain period of time, the twins were measured and compared with previously determined developmental criteria to see whether the enhanced experience affected the experimental child in any way. Co-twin research provided significant contributions to the study of motor development. In particular, these studies allowed developmentalists to begin identifying the sequence of skill development and noting variations in the rate of skill onset. Gesell concluded from his research that children develop in an orderly fashion (i.e., developmental change came in a predictable, predetermined order over childhood).

Another prominent researcher at the time, Myrtle McGraw, used twins to examine the influence of enhanced experience on motor development (Bergenn, Dalton, & Lipsett, 1992; McGraw, 1935). In her classic study, *Growth: A Study of Johnny and Jimmy*, McGraw started observing the twins several months after their birth.



FIGURE 2.1 Using twins in studies allowed researchers such as Gesell and McGraw to “control” genetics while manipulating the environment.

Courtesy of the authors.

She provided one twin (Johnny), at around 12 months of age, with challenging environments and unique tasks such as climbing a ramp at a progressively higher incline and roller skating. The tasks often required both motor and problem-solving skills. Johnny did excel in certain motor skills but not in others, which did little to resolve the nature-versus-nurture debate prominent in psychology at the time. McGraw's results were equivocal, which may have been due (at least in part) to the fact that the twins were fraternal rather than identical.

In addition to describing the course of motor development, many maturationists were interested in the processes underlying development. McGraw (1943), for example, associated changes in motor behavior with development of the nervous system. She considered maturation of the CNS to be the trigger for the appearance of new skills. McGraw was also interested in learning (and therefore not strictly a maturationist), but those who followed in the study of development generally overlooked this aspect of her work (Clark & Whittall, 1989a).

Use of the maturational perspective as a research tool in motor development began to wane by the 1950s, but the theory's influence is still felt today. For example, the focus on maturation as the primary developmental process led researchers and laypersons alike to assume that basic motor skills will automatically materialize. Hence, even today, many researchers, teachers, and practitioners feel it is unnecessary to facilitate development of basic skills. In addition, the maturationists' emphasis on the nervous system as the *one* system triggering behavioral advancement evolved to almost single-minded emphasis on that system—to the point that no other system was believed to have much significance. The cardiovascular, skeletal, endocrine, and even muscular systems were not deemed of primary importance to motor development. By the mid-1940s, developmental psychologists began to change the focus of their research, and their interest in motor development waned. At that point, physical educators took up the study of motor development, influenced by the maturational perspective. From then until about 1970, people studied motor development by describing movement and identifying age group norms (Clark & Whittall, 1989a). During this period, motor developmentalists from the physical education discipline focused their attention on school-age children. Researchers still used the maturational perspective, and their task therefore was to identify the naturally occurring sequence of changes.

KEY POINT

People have interpreted the maturationist perspective to mean that motor skills will automatically emerge regardless of differing environments. This assumption has influenced many teaching, parenting, and research concepts during the 20th and 21st centuries.

Normative Descriptive Period

Anna Espenschade, Ruth Glassow, and G. Lawrence Rarick led a normative description movement during this era. In the 1950s, education became concerned with standardized tests and norms. Consistent with this concern, motor developmentalists began to describe children's average performance in terms of quantitative scores on motor performance tests. For example, they described the average running speed and jumping and throwing distances of children at specific ages. Although motor developmentalists were influenced by the maturational perspective, they focused on the *products* (scores, outcomes) of development rather than on the developmental *processes* that led to these quantitative scores.

Biomechanical Descriptive Period

Ruth Glassow also led another descriptive movement during this era. She made careful biomechanical descriptions of the movement patterns children used in performing fundamental skills such as jumping. Lolas Halverson (figure 2.2) and



FIGURE 2.2 Lolas Halverson paved the way in the 1960s and 1970s for contemporary research in motor development.

Courtesy of the authors.

others continued these biomechanical descriptions with longitudinal observations of children. As a result, the developmentalists were able to identify the course of sequential improvement that children followed in attaining biomechanically efficient movement patterns. The knowledge obtained from the normative and biomechanical descriptive periods was valuable in that it provided educators with information on age-related changes in motor development. Because description prevailed as the primary tool of these researchers during this time, motor development was labeled as descriptive. Interest in the processes underlying age-related changes, which had been so meticulously recorded before this period of history, seemed to disappear.

Information Processing Perspective

Another theoretical approach focuses on behavioral or environmental causes of development (e.g., Bandura's social learning [Bandura, 1986] and Skinner's behaviorism [Skinner, 1938], among others). The perspective most commonly associated from the 1960s to the 1980s with motor behavior and development is called **information processing**. According to this perspective, the brain acts like a computer, taking in information, processing it, and outputting movement. The process of motor learning and development, then, is described in terms of computer-like operations that occur as a result of some external or environmental input.

This theoretical perspective appeared around 1970 and became the dominant perspective among experimental psychologists, developmental psychologists, and motor learning scientists specializing in physical education during the 1970s and 1980s (Schmidt & Lee, 2005; Schmidt & Wrisberg, 2008). This perspective

emphasized concepts such as the formation of stimulus–response bonds, feedback, and knowledge of results (for more detailed information, see Pick, 1989; Schmidt & Wrisberg, 2008). Although some motor developmentalists continued with the product-oriented work of the normative and biological descriptive era, many others adopted the information processing perspective. Researchers studied many aspects of performance, such as attention, memory, and effects of feedback, across age levels (French & Thomas, 1987; Thomas, 1984). Motor learning researchers and experimental psychologists tended to study the perceptual-cognitive mechanism in young adults first. Then, developmentalists studied children and older adults, comparing them with the young adults. In this way, they could identify the processes that control movement and change with development (Clark & Whittall, 1989a). Today, the information processing perspective is still a viable approach to the study of motor development.

Within the framework of information processing, some developmentalists continued to study perceptual-motor development in children. This work began in the 1960s with proposals that linked learning disabilities to children's delayed perceptual-motor development. Early research focused on this link; by the 1970s, researchers had turned their attention to the development of sensory and perceptual abilities, adopting information processing research strategies (Clark & Whittall, 1989a). Therefore, much of what we know about perceptual-motor development resulted from researchers working within an information processing and mechanistic theoretical framework.

Ecological Perspective

KEY POINT

The ecological perspective takes into account many constraints or systems that exist both in the body (e.g., cardiovascular, muscular) and outside the body (e.g., ecosystem related, social, cultural) when observing the development of motor skills across the life span.

A new perspective on development appeared during the 1980s and has become increasingly dominant as the theoretical perspective used by motor development researchers today. This approach is broadly termed the **ecological perspective** because it stresses the interrelationships between the individual, the environment, and the task. Does this sound familiar? It should—it's the perspective adopted by this text! We adopted this perspective because we feel it best describes, explains, and predicts motor development. According to the ecological perspective, you must consider the interaction of all constraints—for example, body type, motivation, temperature, and ball size—in order to understand the emergence of a motor skill—such as kicking (Robertson, 1989). Although one constraint or system may be more important or may cast a larger influence at any given time, all systems play a role in the resultant movement. This point makes the ecological perspective very appealing: At any given moment, how you move is related not only to your body or your environment but also to the complex interplay of many internal and external constraints.

The ecological perspective has two branches, one concerned with motor control and coordination (dynamical systems) and the other with perception (perception–action). The two branches are linked by several fundamental assumptions that differ notably from the maturational and information processing perspectives. In contrast to the maturational perspective, the ecological perspective considers motor development to be the development of multiple systems rather than only one (the CNS). In other words, many constraints change over time and influence motor development. Because these constraints or systems change throughout one's life, motor development is considered a life span process. This contrasts sharply with the view of maturationists, who felt that development ended with the end of

puberty (or at adulthood). Another difference relates to the cause of change. In information processing theory, an executive function is thought to decide all action, based on calculations of perceptual information resulting in hundreds of commands to control the individual muscles. That is, the executive directs all movement and all change. The ecological perspective maintains that a central executive would be overwhelmed by the task of directing all movement and change. In addition, this is a very inefficient way to move. Rather, perception of the environment is direct, and muscles self-assemble into groups, reducing the number of decisions required of the higher brain centers (Konczak, 1990). Let's look more closely now at each branch of the ecological perspective.

Dynamical Systems Approach

One branch of the ecological systems perspective is called the **dynamical systems approach**. In the early 1980s, a group of scientists—working at Haskins Laboratory in New Haven, Connecticut, whose mission was and remains to research spoken and written language, and in the psychology department at the University of Connecticut—began to question the effectiveness of understanding motor control through the then-dominant information processing perspective. Peter Kugler, Scott Kelso, and Michael Turvey (1980, 1982), along with others from UConn and Haskins Laboratory, introduced a new approach, called dynamical systems, as an alternative to existing motor control and coordination theories. Following the writings of Soviet physiologist Nikolai Bernstein, they suggested that the very organization of physical and chemical systems constrains behavior. Think about it: Your body can move in many different ways. However, because of the structure of your hip joints and legs (part of your skeletal system), you, as an adult, tend to walk (as opposed to crawl, scoot, or squirm) as a primary mode of transportation. Thus, the structural organization of your body encourages—constrains—you to walk. In other words, your body's structure removes some of the movement choices your CNS might have to make (i.e., among crawling, scooting, squirming, or walking). It's not that you cannot perform these movements; it's just that because of your body structure, you are more attracted to (or constrained to) walking.



Imagine that a human infant is born in a space station on the moon. Predict the types of movements you would see during the first 2 years of life. In particular, how would you expect the infant to get around?

Unlike the maturational and information processing perspectives, the dynamical systems approach suggests that coordinated behavior is softly assembled rather than hardwired, meaning that the interacting constraints in your body act together as a functional unit to enable you to walk when you need to. By *not* having a hardwired plan, you have greater flexibility in walking, which allows you to adapt your walk to many different situations. This process is called spontaneous self-organization of body systems. As we state in chapter 1, movement emerges from the interaction between constraints (individual, environmental, task). The resultant behavior emerges or self-organizes from these interrelationships. If you change any one of them, the emergent movement may change (Clark, 1995). This is the concept of constraints in the dynamical systems approach.

An important motor development concept produced by the dynamical systems approach is the notion of **rate limiters**, or **controllers**. The body's systems do not develop at the same rate; rather, some might mature quickly and others more slowly,

A rate limiter, or controller, is an individual constraint or system that holds back or slows the emergence of a motor skill.

and each system should be considered a constraint. Consider the hypothetical example graphed in figure 2.3. The development of four hypothetical systems is pictured in each of the small graphs numbered 1 to 4. As time passes, the development of system 1 remains at a constant value. System 2 plateaus, advances in a large step, then plateaus again. System 3 advances gradually and more continuously, whereas system 4 alternately advances and plateaus in a steplike fashion. The exhibited behavior, represented in the large graph, is affected by all the individual systems as they interact among themselves and with the task and environment.

An individual might begin to perform a new skill, such as walking, *only* when the slowest of the necessary systems for that skill reaches a certain point. Any such system or set of systems is known as a rate limiter, or controller, for that skill because that system's development controls the individual's rate of development at that time. In other words, the system acts as a constraint that discourages the motor skill until the system reaches a specific, critical level. Suppose that system 4 in figure 2.3 is the muscular system. Perhaps an infant's muscular strength must reach a certain level before the legs are strong enough to support the infant's weight on one leg in order to walk. Hence, muscular strength would be a rate limiter, or controller, for walking. Until the infant reaches a critical level of leg strength (enough to support the body), strength discourages walking and encourages other forms of transportation, such as creeping, crawling, or rolling. The notion of rate limiters fits well in the model of constraints.

These tenets of the dynamical systems approach differ significantly from those of the maturational perspective. Maturationists tend to focus on the CNS as the only system relevant to development and the only rate controller. The dynamical systems approach focuses on many systems and acknowledges that different systems might act as rate controllers for different skills (Thelen, 1998).



In your experience, what rate limiters have affected your motor behavior? How have these changed at different times in your life?

Another feature of the dynamical systems approach is that it allows for the study of development across the life span. The concept of a system acting as a rate limiter, or controller, for a movement behavior applies into older adulthood as well.

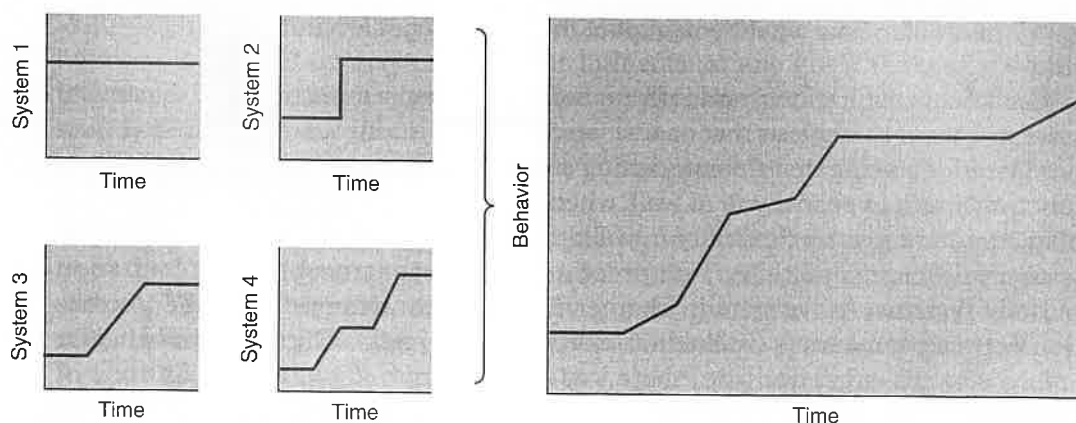


FIGURE 2.3 Four developing systems are depicted as contributing to behavior in an environmental context and for some particular task. The horizontal axis is time, and the vertical axis represents several parallel systems (which act as constraints) developing in different ways.

Adapted by permission from Thelen, Ulrich, and Jensen 1989.

The maturational perspective does not address aging because the predetermined endpoint of motor development is maturation, which occurs in the first several decades of life. In contrast, the dynamical systems approach accounts for changes in older adults as well as advancement in youths. When one or more of an individual's systems has declined to a critical point, a change in behavior might occur. This system is a rate controller; because it is the first to decline to some critical point, it triggers the reorganization of a movement to a less-efficient pattern. For example, if an individual's shoulder joint deteriorates as a result of arthritis and loses flexibility, at some point that individual might have to use a different overhand throwing motion or even throw underhand. The dynamical systems approach is appropriate for explaining developmental changes because changes do not necessarily occur in all systems over the entire span of older adulthood. Disease or injury may strike one system, and systems may be differentially affected by lifestyle. An active older adult who maintains a regular and balanced exercise program may experience fewer declines in many of the systems than a sedentary peer does.

Perception–Action Approach

The second branch of the ecological perspective is the **perception–action approach**. J.J. Gibson proposed this model in his writings during the 1960s and 1970s (1966, 1979), but those who study movement have only recently adopted this approach. Gibson proposed that a close interrelationship exists between the perceptual system and the motor system and emphasized that these systems evolved together in animals and humans. In this approach, we cannot study perception independent of movement if our findings are to be *ecologically valid*—that is, applicable to real-world movement behavior. Likewise, the *development* of perception and the *development* of movement must be studied together. In addition, we cannot study the individual while ignoring the surrounding environment. Gibson used the term **affordance** to describe the function an environmental object provides to an individual; this is related to the size and shape of the object and the individual in a particular setting. For example, a horizontal surface affords a human a place to sit, but a vertical surface does not. A squirrel can rest on a vertical tree trunk, so a vertical surface affords a squirrel a resting place. A baseball bat affords an adult, but not an infant, the opportunity to swing. Hence, the relationship between individual and environment is so intertwined that one's characteristics define objects' meanings, which implies that people assess environmental properties in relation to themselves, not according to an objective standard (Konczak, 1990). For example, an individual perceiving whether he or she can walk up a flight of stairs with alternating footsteps considers not just the height of each stair alone but also the height of each stair in relation to the climber's body size. A comfortable step height for an adult is not the same as that for a toddler. The use of intrinsic (relative to body size) rather than extrinsic dimensions is termed **body scaling**.

When a person looks at an object, he or she directly perceives the function that the object will allow, based both on his or her body and on the object's size, shape, texture, and so forth. This function is called a **affordance**.

Body scaling is the process of changing the dimensions of the environment or an environmental object in relation to the structural constraints of a performer.



WEB STUDY GUIDE Create body-scaled contexts for individuals with different disabilities by doing Lab Activity 2.1, **Equipment That Affords Action**, in the web study guide. Go to www.HumanKinetics.com/LifeSpanMotorDevelopment.

The implications of these ideas for motor development are that affordances change as individuals change, resulting in new movement patterns. Growth in size, for example, or enhancement in movement capabilities, might allow actions

KEY POINT

The concept of body scaling means that an object, though possessing an absolute size and shape, affords a function *relative* to the size and shape of the person using it. An activity may become easier or more difficult if the equipment size is changed relative to a person's body dimensions.

not previously afforded. When an infant first faces stairs, her perception of their function is not likely to be one of "climbability" because of her small size and relative lack of strength. As a toddler, though, she grows to a size that makes climbing stairs with alternating footsteps easy. Scaling environmental objects to one's body size permits one to conceive of actions that otherwise seem impossible. Body scaling also applies to other age periods. For example, steps that are an appropriate height for most adults might be too high for an older adult with arthritis to climb comfortably with alternating footsteps. A wall-mounted light switch might be at a comfortable height for most adults yet rest a frustrating inch too high for someone sitting in a wheelchair. At any age, achievement of a movement goal relates to the individual, who is a certain shape and size, and to environmental objects, which afford certain movements to that individual.

Viewed another way, body scaling represents an excellent example of the interaction or interface between individual and task constraints. When walking up stairs, individuals must relate the length of their legs, their strength, and their dynamical range of motion (individual constraints) to the height of the stairs they are about to step on (task constraint). Changes in constraints, such as an ankle sprain, high-heeled shoes, or an icy staircase, will result in changes in the way an individual steps on the stairs. In physical education settings, instructors often assist children in body scaling by providing them with smaller equipment that is more appropriate for their smaller body size. By doing so, instructors manipulate the interaction between individual and task constraints to encourage a more advanced movement pattern (Gagen & Getchell, 2004).



What activities would a 10-speed bicycle afford an infant, a typically able adult, an individual with paraplegia, or a chimpanzee? What individual constraints affect the activities afforded to each?

Gibson also rejected the notion of a CNS executive that performs almost limitless calculations on stimulus information to determine the speed and direction of both the person and the moving objects. The information processing perspective holds that such calculations are used to anticipate future positions so that we can, for example, reach up to catch a thrown ball. Instead, according to Gibson, individuals perceive their environment directly by constantly moving their eyes, heads, and bodies. This activity creates an optic flow field that provides both space and time information. For example, the image of a baseball approaching a batter not only indicates the ball's location but also expands on the eye's retina, and the batter uses the rate of image expansion to time his swing—that is, the rate of expansion gives the batter's CNS direct information about when the ball will be in range. Likewise, the expansion rate of the image of an oncoming car on a driver's retina yields the time to collision. From Gibson's perspective, an individual can perceive time to collision directly and does not need to perform a complicated calculation of speeds and distances to predict where and when collisions and interceptions will occur.

The ecological perspective has been taking hold in motor development research throughout the past two decades. Developmentalists are asking different types of questions: How does an infant's immediate environment affect her motor behavior? What constraints act as rate limiters to children's throwing? How will changing specific individual constraints in a rehabilitation setting alter motor patterns? Concurrently, they have developed types of research studies, such as examining the relationship between infant reflexes and adult movements (Thelen & Ulrich, 1991). The ecological perspective encourages professionals to view developing

individuals in a very different way than before. As a result, these perspectives will excite and challenge students in the field. In many sections of this text, we examine the maturation and dynamical systems approaches on a particular issue and highlight the differences between these perspectives.

Summary and Synthesis

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This chapter reviews the history and theoretical viewpoints specific to motor development—the maturational, information processing, and ecological perspectives. The maturational perspective emphasizes biological development, specifically maturation of the CNS. The information processing perspective sees the environment as the main force driving motor development. Unlike followers of the previous perspectives, ecological theorists stress interaction between all body systems (or, as Newell called them, constraints) as well as the inseparable factors of individual, environment, and task. In the ecological perspective, two related approaches to research exist: dynamical systems and perception–action approaches. This textbook adopts an ecological perspective and focuses on how individual, environmental, and task constraints interact to encourage or discourage movements. The concepts of rate limiters, or controllers, and body scaling exemplify how a motor developmentalist must consider the individual’s performance of a particular task in a given environment in order to fully understand individuals’ motor development over the course of a lifetime.

Diametrically opposed perspectives cannot be merged, but students of motor development are free to view behavior from different perspectives. It is important to remember that these theoretical viewpoints often focus only on specific aspects of development; that is, developmentalists with a particular perspective tend to study certain behaviors or age spans. Maturationists focus on infancy, whereas descriptive developmentalists focus on late childhood and adolescence. Information processing theorists search for age differences, whereas those studying from an ecological perspective observe transitions from one skill to another (e.g., from crawling to walking).



Reinforcing What You Have Learned About Constraints

TAKE A SECOND LOOK

Let’s revisit the first 18 months of your hypothetical nephew’s life from an ecological perspective. Thinking about his first week of life, what constraints most influence his motor behavior? That is, what rate limiters keep him moving the way he does? As we suggest in chapter 1, in order to understand developmental change, we should think about where he was, where he is, and where he will be. The first big change, therefore, would be moving from an aqueous environment (his mother’s womb) to one where gravity’s full force can be felt. Keeping this in mind, part of the reason your nephew may move his arms in a seemingly uncoordinated fashion may relate to his strength (or lack thereof). As his environment changes, a need is created for greater strength to move his arms (individual–environmental constraint interaction). Over time, he builds strength, which interacts with other developing systems. When you see him at 9 months, all the systems have converged to allow him to use his arms more effectively. In terms of the rate limiter of strength, he has reached a critical level that allows him to move more functionally. He has sufficient strength to sit up, move his

arm toward a toy, grasp it, and bring it to his mouth. He even has enough strength to stand on both legs and support his weight (with a little help from you).

Consider his next objective: moving independently around his environment. He might eye a chair (which to you affords sitting), scale the height of the seat to the length of his trunk, and pull himself up to a standing position. Can he walk yet? Probably not, as another rate limiter—balance—prevents him from standing alone unsupported. We could go on and on, examining the different ways in which your nephew uses affordances and body scaling, and you can think of examples on your own. Hopefully the interactions between the various constraints become clearer and clearer to you, and by the end of the text you will naturally evaluate the influence of different constraints on motor development.

TEST YOUR KNOWLEDGE

1. List the key researchers in the field of motor development from the maturational, information processing, and ecological perspectives.
2. How can a physical educator or physical therapist use the concept of body scaling to help individuals develop motor skills?
3. Why should physical educators be interested in affordances?
4. Explain, based on the different theoretical perspectives, how an infant learns to walk. What are the most important influences on the infant, according to each perspective?

LEARNING EXERCISE 2.1

Body Scaling to Design Sport Equipment

You have been hired by Haywood's Tennis Supplies to design a line of body-scaled tennis rackets. Because the company would like to distinguish its product line from others on the market, you must prepare an initial report addressing important aspects of the new rackets, available product lines from other companies, and how your rackets will be different. Develop this report; you can use the following questions as a guide.

1. What are the important individual constraints to consider when body scaling tennis rackets?
2. How have other companies body scaled their rackets? On what individual constraint or constraints do they scale?
3. What are some novel ways to scale Haywood's new rackets? What have other companies overlooked?

LEARNING EXERCISE 2.2

Hunting for Rate Limiters in Everyday Situations

Physical educators, physical therapists, parents, and many others want to encourage proficient motor skills in those with whom they interact. One important consideration in working to improve motor skill performance is this: What is holding a person back, or limiting the rate at which he or she acquires a skill? In this exercise you will determine the key rate limiter for a particular skill, given the constraints described.

1. An 11-month-old infant can use furniture to pull himself upright, can cruise the length of the couch if he keeps one hand in contact, and can push a toy shopping cart down the hall. However, when placed standing in the center of the room, he does not walk but rather gets down on all fours and crawls. What is his primary rate limiter for walking?

2. A stroke patient has control over her limbs and has little difficulty walking. She can lift a pencil and write lists and letters. She can comb her hair and brush her teeth. She experiences problems, however, when she tries to lift cans and jars overhead onto shelves. What is her primary rate limiter for reaching?
3. A 5-year-old can easily walk, run, jump, and hop. She plays games with other children on the playground and is very attentive in physical education class. She has problems, however, with galloping and skipping; she cannot seem to master the asymmetrical rhythms of these skills. What is her primary rate limiter for galloping and skipping?