CHAPTER 3

Motor Abilities

Concept: A variety of abilities underlie motor skill learning and performance success.

After completing this chapter, you will be able to

- Define the term *ability* and distinguish it from the term *skill*
- Explain the difference between the general motor ability hypothesis and the specificity of motor abilities hypothesis
- Name and describe several motor ability categories and explain how researchers have identified the various motor ability categories
- Describe how motor abilities relate to motor skill performance

APPLICATION

Some people perform many different physical activities very well. Why is this the case? Are they born with some special "motor ability" that enables them to be successful at all they do? Have they had an abundance of good training and practice in a wide variety of activities? Are they really good at everything, or only at certain activities?

Also, people differ in how quickly and successfully they learn motor skills. If you observe a physical activity class for beginners, you will see various degrees of success and failure during the first few days. For example, in a beginning golf class, when the students first start to hit the ball, some will spend an inordinate amount of time simply trying to make contact with the ball. But some will be at the other extreme, able to hit the ball rather well. The remainder of the class usually will be distributed somewhere along the continuum of success between these two extremes. We can observe parallel differences in other physical activity situations such as dance classes, driving instruction classes, and physical therapy sessions.

The understanding of the role played by motor abilities in the learning and performance of motor skills can help explain some of the differences we observe in how well people perform skills. The benefit of this understanding for practitioners is that it can provide the basis for carrying out specific aspects of their work, such as interpreting skill performance assessments, developing effective methods to help people overcome performance deficits, acquire new skills, and enhance performance of well-learned skills.

Application Problem to Solve Select a motor skill that you perform for recreational or sports purposes. Other than for reasons related to the quality and amount of instruction or coaching and practice, why do some people perform this skill at a higher level than you and some perform it at a lower level?

DISCUSSION

In chapters 1 and 2, you were introduced to motor skills and the measurement of motor skill performance. Now, you will be introduced to a type of personal characteristic known as *ability,* which influences the way people perform and learn motor skills.

ABILITY AND MOTOR ABILITY

One of the difficulties in studying the concept of ability as it relates to motor skill performance is that the term *ability* is used in so many different ways. For example, physical and occupational therapists refer to "functional ability"; a baseball coach might refer to a player's "running ability"; educators often refer to students' "cognitive ability" or "intellectual ability." The list of examples could go on, but these few examples illustrate the problem. As a result, it is important to specify the precise manner in which the term will be used.

For this discussion, the term *ability* will be used according to its meaning in the area of psychology that involves the study of *individual differences.* People who study individual differences are concerned with the identification and measurement of abilities that characterize and differentiate individuals. Individual-difference psychologists also investigate the relationship between abilities and the performance and learning of skills. In this context, the term **ability** means *a general trait or capacity of the individual that is a relatively enduring characteristic that serves as a determinant of a person's achievement potential for the performance of specific skills.* When the term **motor ability** is used in this context, it refers to *an ability that is specifically related to the performance of a motor skill.* It is important to note that some researchers and practitioners use terms such as "psychomotor ability" and "perceptual motor ability" to refer to what we will call motor ability.[1]

The identification of specific motor abilities is not an easy task. As a result, few researchers have ventured into this area of study. However, those who have undertaken this challenge have provided us with useful information that helps us have a better understanding of an important factor related to determining why people differ in achievement levels of motor skill performance.

[1]Although the terms *motor ability, psychomotor ability,* and *perceptual-motor ability* can have specific meanings, they are sufficiently similar, for purposes of this book, to use the term *motor ability* to refer to all three terms.

Abilities as Individual-Difference Variables

The individual differences we observe in the amount of success that people achieve in the performance of a motor skill depends in large part on the degree to which the person has the motor abilities that are important for the performance of that skill. For example, people with differing levels of the motor abilities important for playing tennis will have differing *achievement potentials* in tennis. This example indicates that various motor abilities underlie the performance of a complex motor skill such as tennis and that people have different levels of these abilities. It also indicates that if two people have the same training experiences and amount of practice, but differ in their levels of the motor abilities important for playing tennis, the one with the higher levels of the appropriate abilities has the potential to perform at a higher level. Although researchers generally agree with this view, they debated for many years, especially in the 1950s and 1960s, how motor abilities relate to one another within the same person.

General versus specific motor abilities. In the debate about the relationship of motor abilities, one viewpoint holds that motor abilities are *highly related* to each other. The opposite view is that they are *relatively independent* of one another. This debate is not commonly pursued in the current research literature. However, an understanding of the different points of view will help you apply the concept of motor abilities to motor skill performance achievement.

The **general motor ability hypothesis** maintains that although many different motor abilities can be identified within an individual, they are highly related and can be characterized in terms of a singular, global motor ability. It holds that the level of that ability in an individual influences the ultimate success that person can expect in performing any motor skill. This viewpoint has been in existence since the early part of the last century (e.g., Brace, 1927; McCloy, 1934), having been developed as the motor ability analogue to the then popular cognitive ability concept of a general intelligence (IQ). The hypothesis predicts that if a person is highly skilled in one motor skill, then he or she would be expected to be or become highly skilled in all motor skills. The reasoning behind this prediction is that there is *one* general motor ability. In fact, one proponent of this view developed a motor ability test battery that he proposed could be used to classify students into one of five homogeneous motor ability subgroups for purposes of teaching and engaging in physical activities (Barrow, 1957).

But contrary to the expectations of proponents of the general motor ability hypothesis, very little research evidence supports this viewpoint. One suspects that the basis for the continued existence of this hypothesis is its intuitive appeal. Tests of general motor ability are convenient, appealing to those who seek an easy explanation for why certain people are successful or unsuccessful at performing motor skills. The fact that these tests are poor predictors of specific motor skill performance has not diminished the appeal of the general motor ability hypothesis.

The alternative perspective, for which there has been substantial support, is the **specificity of motor abilities hypothesis**. Franklin Henry is generally credited with deriving the specificity hypothesis to explain results from his research that the general motor ability hypothesis could not explain. This specificity view states that individuals have many motor abilities, and these abilities are relatively *independent.* This means, for example, that if a person exhibited a high degree of balancing ability, we could not predict how well that person would do on a test of reaction time.

Support for the specificity hypothesis has come from experiments that were reported primarily in the 1960s. These experiments were based on the common assumption that if motor abilities are specific and independent, then there will be little, if any, relationship between any two abilities. Thus, in the simplest of cases, there would be little, if any, relationship between abilities such as balance and reaction time, or between reaction time and speed of movement, or between static and dynamic balance.

The research evidence that provided most of the initial support for the specificity hypothesis, and became an impetus for further research, came from Franklin Henry's laboratory at the University of California, Berkeley. This research was based on the premise that motor abilities are relatively independent. Henry and his colleagues reasoned that they could demonstrate this independence rather simply by investigating the relationship between reaction time and arm movement speed. Recall from the discussion in chapter 2 that reaction time is the amount of time to see, hear, or feel a stimulus (i.e., a "go" signal) and then initiate the required movement; movement time is the amount of time from the initiation of the movement to its completion. The common result from many experiments from Henry's laboratory (e.g., Henry, 1961a, 1961b) was that reaction time and movement speed are uncorrelated,[2] which means that each is an independent motor ability.

Balance and Timing Abilities

Although researchers now generally accept the specificity of motor abilities hypothesis, some have raised questions about the generality of certain specific motor abilities. That is, do certain motor abilities represent one ability, or are there several variations of these abilities, each of which is task specific and relatively independent of the other(s)? Two examples of these motor abilities, which are especially relevant to our discussions in this book, are balance and timing.

[2]Note that the term "uncorrelated" refers to a statistical assessment of the relationship between two or more variables, known as a correlation, which can range between uncorrelated, indicating no relationship, and highly correlated, indicating a strong relationship between the variables.

ability a general trait or capacity of an individual that is a determinant of a person's achievement potential for the performance of specific skills.

motor ability an ability that is specifically related to the performance of a motor skill.

general motor ability hypothesis a hypothesis that maintains that the many different motor abilities that exist in an individual are highly related and can be characterized in terms of a singular, global motor ability.

specificity of motor abilities hypothesis a hypothesis that maintains that the many motor abilities in an individual are relatively independent.

Balance. When used in reference to motor skill performance, the term *balance* refers to *postural stability* (see Shumway-Cook & Wollacott, 2017), which involves maintaining equilibrium while stationary or while moving. In other words, balance concerns our capability to stand, sit, or move without falling. Although sometimes regarded as a single motor ability, balance should be viewed as comprised of at least two types: static and dynamic. *Static balance* is the maintenance of equilibrium while stationary, such as while standing, sitting, or kneeling. *Dynamic balance,* on the other hand, is the maintenance of equilibrium while in motion, such as while walking or running. Static balance is sometimes considered to be a simpler variation of dynamic balance. This viewpoint is seen, for example, when rehabilitation protocols specify that a person should develop static postural balance capabilities before engaging in activities requiring dynamic postural balance, such as walking. However, research evidence consistently indicates that static and dynamic balance are relatively independent motor abilities. For example, Rose et al. (2002) reported that fourteen of twenty-three children with gait disorders related to cerebral palsy showed normal standing balance characteristics.

Research evidence also indicates that several relatively independent variations of static and dynamic balance exist. Drowatzky and Zuccato (1967) reported an excellent example of this research many years ago. In this experiment, participants performed six different balancing tasks that generally have been regarded as measures of either static or dynamic balancing ability. The results of the correlations among all the tests (table 3.1) showed that the highest correlation (.31) was between two dynamic balance tests, the sideward leap and the Bass stepping stone test. The highest correlation between a static and dynamic balance test was .26 (between the stork stand and sideward leap). Most of the correlations ranged between .12 and .19. The Drowatzky and Zuccato results are not unique. Other researchers have found similar results. For example, a study by Giboin, Gruber, and Kramer (2015) reported highly task-specific balance task training effects by showing that participants who trained with a specific balance task performed better on the task on which they trained for two weeks than on a balance task on which they had not trained. Also, Ringhof and Stein (2018) found performance by female gymnasts and swimmers on three dynamic balance tests (landing from one-leg jumps, perturbations on an unstable platform, and balance recovery after simulated forward falls) resulted in low between-test correlations. Both of these studies support the idea that balance is not a unified ability. It is also worth noting that researchers have found that highly related static and dynamic balance tests, standing on one leg and stabilizing the body after landing on one leg, are not highly correlated with each other (Pau et al., 2015).

On the basis of results such as these, *it would be difficult to conclude that only one test could be considered a valid measure of balancing ability.* At the most basic level, we need to consider static balance and dynamic balance as two independent types of balance ability. The application of the relative independence of static and dynamic balance to professional practice can be seen in several of the balance tests commonly used in physical rehabilitation contexts. For example, the Berg Balance Scale (BBS), which is one of the most commonly used balance tests, involves fourteen types of static and dynamic tests of balance. Research evidence has shown that the BBS can be a useful assessment tool in a variety of contexts, such as determining the risk of falling by the elderly and evaluating treatment effects for post-stroke patients (see Blum & Korner-Bitensky, 2008), though the evidence to support these functions is weak (Lima, Ricci, Nogueira, & Perracini, 2018). Many other balance tests have been developed that also include the use of multiple static and dynamic activities. Research has shown that these tests are for use with specific

LAB LINKS

Lab 3 in the Online Learning Center Lab Manual for chapter 3 provides an opportunity for you to experience several different types of balance tests and compare your results to the predictions of the general motor ability and specificity of motor abilities hypotheses.

TABLE 3.1 Results from the Experiment by Drowatzky and Zuccato (1967) Showing the Correlations among Six Different Tests of Static and Dynamic Balance

	Static Balance Tests			Dynamic Balance Tests		
	1	2	3	4	5	6
Test	Stork Stand[a]	Diver's Stand[b]	Bass Stick Stand[c]	Sideward Leap[d]	Bass Stepping Stone Test[e]	Balance Beam Test[f]
1	—	.14	−.12	.26	.20	.03
2		—	−.12	−.03	−.07	−.14
3			—	−.04	.22	−.19
4				—	.31	.19
5					—	.18
6						—

[a]*Stork stand*—Person stands for as long as possible on the foot of the dominant leg while placing the other foot on the inside of the supporting knee and the hands on the hips.

[b]*Diver's stand*—Person stands erect with both feet together, arms extended in front. When ready he or she rises onto the balls of the feet, closes his or her eyes, and maintains this position for as long as possible.

[c]*Bass stick test*—Person stands for as long as possible, up to 60 sec, with the ball of the foot of the dominant leg crosswise on a 1 in. wide × 1 in. high × 12 in. long stick; the other foot must be off the floor.

[d]*Sideward leap*—Person stands on the left foot, leaps sideward to the right to a mark on the floor (distance = person's leg length), leans forward to push small object off a mark (18 in. in front of landing mark), then holds balance for 5 sec.

[e]*Bass stepping stone test*—Person stands on the right foot on the starting mark, then leaps to a series of targets located in front of the person, alternating left and right feet. At each target, the person maintains balance for as long as possible, up to 5 sec.

[f]*Balance beam test*—On a balance beam (4 in. wide, 4.5 in. off the floor, 10 ft long) person walks, with hands on hips, heel to toe for 10 steps or until falls; if falls, gets back on beam, continues walking; stops walking at 10 steps or second fall.

Source: From Drowatzky, J. N., & Zuccato, F. C. (1967). Interrelationships between selected measures of static and dynamic balance. *Research Quarterly for Exercise and Sport, 38,* 509–510. 1967 American Alliance for Health, Physical Education, Recreation, and Dance.

populations and for specific purposes (e.g., Cattaneo, Jonsdottir, & Repetti, 2007; Haines et al., 2007; Rose, Lucchese, & Wiersma, 2006; Verbecque, Da Costa, Vereeck, & Hallemans, 2015). The important conclusion to draw from the research on balance tests is that *balance is a multidimensional ability* that is specific to the task or skill in which balance is involved, with static and dynamic balance viewed as general categories of types of balance.

Timing. As a motor ability, timing is an important component of the performance of many motor skills. For some skills we need to precisely time our movement initiation with the movement of an external object, such as hitting a moving baseball or starting a sprint in track. This type of timing is commonly referred to as *external,* or *anticipation, timing.* For other skills, we time our movements according to our knowledge of time, which occurs when we walk or jog at a desired pace or when a dancer performs without music but must maintain a specific rhythm and tempo. This type of timing is known as *internal timing.* In the study of individual differences, researchers have held different views about internal timing as a motor ability. One view proposes that timing is controlled by a common timing process, much like an internal clock, that provides the musculature with the rhythmic information needed to produce the continuous timing requirements of a skill (e.g., Ivry & Hazeltine, 1995). An alternate view argues that the precise rhythmic timing we observe results from task-specific characteristics related to the interaction between the person and the performance environment.

One of the ways researchers have tested views about the control of internal timing is to follow the approach used to test the specificity of motor abilities hypothesis that we discussed earlier. If an "internal clock" controls timing, we would expect a general ability for timing, and therefore people should perform similarly across a variety of tasks that require timing. On the other hand, if timing is task specific, performance on one type of task should not predict how well we would perform on a different task. These two possibilities were first tested in a series of experiments by Robertson and her colleagues (Robertson et al., 1999). Included in these experiments was a comparison of the performance of two tasks that included the same timing requirement, a series of 800 msec simple movements. One task required participants to repetitively tap an index finger on a tabletop at a speed of 800 msec per tap; the other required repetitive circle drawing at 800 msec per circle. Participants were initially provided a metronome as a guide so they could become familiar with the 800 msec rate of movement. Then the metronome stopped, and participants continued to tap or draw circles as a test of their timing ability. The results showed a low correlation between the two tasks, which indicated that performance on either of the two tasks did not predict how well participants would perform on the other task. Additional research by Zelaznik and his colleagues has shown similar results for repetitive movements performed at the participants' preferred rate of speed (e.g., Zelaznik, Spencer, & Doffin, 2000).

Looking at results based on statistical correlation analysis is not the only way to determine whether timing is a general or task-specific ability. Spencer and Zelaznik (2003) compared timing accuracy for several tasks that required a common timing of several simple movements. If timing is a general ability, we would expect timing accuracy to be similar across these tasks. But, as figure 3.1 shows, the participants varied greatly in how accurately they could time a 500 msec (i.e., 0.5 sec) movement for repetitive finger tapping, line drawing (horizontal and vertical lines of the same

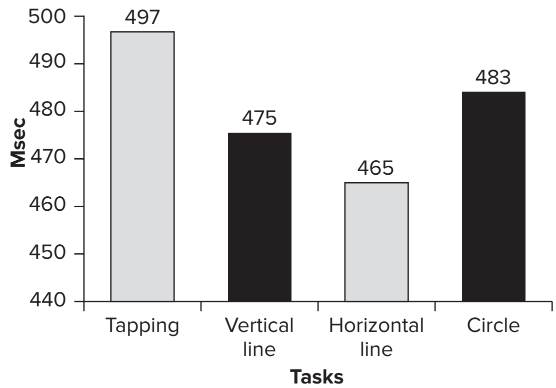

FIGURE 3.1 Results of the experiment by Spencer and Zelaznik (2003) showing the accuracy for timing 500 msec movements when performing tasks that required repetitive finger tapping, drawing vertical and horizontal lines of the same length, and drawing a circle. *Source:* Data from Spencer, R. M. C., & Zelaznik, H. N. (2003). Weber (slope) analyses of timing variability in tapping and drawing tasks. *Journal of Motor Behavior, 35,* 371–381.

length), and circle drawing. Although they very accurately timed their finger tapping, their timing accuracy for the other tasks was notably poorer.

A considerable amount of evidence now exists to support the conclusion that although people are capable of precise timing when performing motor skills, timing ability is specific to the requirements of the skill being performed rather than a general timing ability.

The "All-Around Athlete"

You have undoubtedly read about professional athletes who could have become a professional in several sports. Or perhaps you know people who seem to be "good at" many different physical activities. If motor abilities are numerous and independent, then how can we explain these people whom we often hear referred to as an "all-around athlete," the person who is very proficient at a variety of physical activities? According to the specificity view, abilities fall somewhere along a range containing low, average, and high amounts within individuals. Because people differ in a way that is consistent with a normal distribution scale, we would expect that some people have a large number of abilities at an average level,

A CLOSER LOOK

The Relationship between Falls among the Elderly and Balance

A common problem for the elderly is falling. Both clinicians and researchers have determined that among the many reasons for why the elderly fall, difficulty maintaining balance is one of the primary causes. Thus it is not surprising that the assessment of balance is important for identifying people who may be more at risk for falling than others. At the forefront of developing falls prevention programs is the Center for Successful Aging at California State University at Fullerton (http://hdcs.fullerton.edu/csa/). A publication in 2006 by a group from this center (Rose, Lucchese, & Wiersma, 2006) discussed the development of a balance test the center has successfully used as part of its programs. The following is a summary of some of the information they reported concerning the incidence of falling among the elderly and the test they developed. One of the noteworthy features of the test is that it is based on a multidimensional view of balance, which has been emphasized in this chapter.

Falling Incidence among the Elderly

- 35 percent of people aged over 65 years fall at least once a year
- 20–30 percent of these falls result in injuries that affect mobility and independence

The Fullerton Advanced Balance Scale (FAB)

Although many tests are available to assess a person's risk of falling, the Center for Successful Aging determined that a new test was needed to overcome specific problems associated with available tests. The result was the development of a multidimensional test designed to "identify balance problems of varying severity in functionally independent older adults and also evaluate more of the system(s) (e.g., sensory, musculoskeletal, neuromuscular) that might be contributing to balance problems" (p. 1478). The FAB consists of 10 items that require approximately 10 to 12 min to administer. Table 3.2 summarizes the items and the primary physiological systems or mechanisms each item assesses. A complete description of the test items, the scoring for each item, and the psychometric evaluations of the test are presented in the article.

and other people have a majority of abilities at either the high or the low end of the scale.

According to the specificity hypothesis, the person who excels in a large number of physical activities has high levels of a large number of abilities. We would expect that a person would do very well in those activities for which the underlying abilities required for successful performance matched the abilities for which the person was at the high end of the scale.

In actual fact, the true all-around athlete is a rare individual. Typically, when a person shows high performance levels in a variety of physical activities, a close inspection of those activities reveals they involve many foundational motor abilities in common. We would expect a person exhibiting high levels for a variety of abilities to do well in activities for which those abilities were foundational to performance. However, we would expect average performance if this person engaged in activities for which those abilities were less important, activities based on other abilities, of which the person possessed only average levels.

Identifying Motor Abilities

As a general trait or capacity, an ability is a relatively enduring attribute of an individual. Researchers who study individual differences assume that we can describe the skills involved in complex motor activities in terms of the abilities that underlie their performance. For example, the ability called spatial visualization is related to the performance of such diverse tasks as aerial navigation, blueprint reading, and dentistry. An important step in understanding how abilities and skill performance are related is identifying abilities and matching them with the skills involved.

When researchers and practitioners identify specific motor abilities, they usually refer to the work of Edwin Fleishman (see Fleishman & Quaintance,

A CLOSER LOOK (*Continued*)

The Relationship between Falls among the Elderly and Balance

TABLE 3.2 Test Items and Primary Physiological Systems or Mechanisms Evaluated by Each Item

Test Item	Systems and/or Mechanisms Evaluated
1. Stand with feet together and eyes closed	Sensory systems and strategies (somatosensation, vision), internal representations, musculoskeletal components, neuromuscular synergies
2. Reach forward to object	Sensory systems (vision), neuromuscular response synergies, musculoskeletal components, anticipatory mechanisms
3. Turn in full circle	Sensory systems and strategies (vestibular, vision), neuromuscular synergies, musculoskeletal components
4. Step up and over	Sensory systems and strategies (vision, somatosensation), anticipatory and adaptive mechanisms, neuromuscular synergies, musculoskeletal system
5. Tandem walk	Sensory systems and strategies (vision, somatosensation), neuromuscular synergies, musculoskeletal components
6. Stand on one leg	Sensory systems (vision), anticipatory and adaptive mechanisms, musculoskeletal components
7. Stand on foam with eyes closed	Sensory systems and strategies (vestibular), internal representations, neuromuscular synergies, musculoskeletal components
8. Two-footed jump	Neuromuscular synergies, musculoskeletal components, anticipatory and adaptive mechanisms
9. Walk with head turns	Sensory systems and strategies (vestibular, vision), neuromuscular synergies, adaptive mechanisms
10. Reactive postural control	Neuromuscular synergies, adaptive mechanisms, musculoskeletal system

Source: Adapted from Table 1, p. 1480, in Rose, D. J., Lucchese, N., & Wiersma, L. D. (2006). Development of a multidimensional balance scale for use with functionally independent older adults. *Archives of Physical Medicine and Rehabilitation, 87,* 1478–1485.

1984, for a description of this work). His pioneering research, which was carried out for four decades beginning in the 1950s, continues to influence our understanding and study of motor abilities and how they relate to motor skill performance. Perhaps the most significant achievement of Fleishman's work was the development of a taxonomy of abilities that includes a taxonomy of motor abilities.

A taxonomy of motor abilities. From the results of extensive batteries of perceptual motor tests given to many people, Fleishman developed a "taxonomy of human perceptual motor abilities" (Fleishman, 1972; Fleishman & Quaintance, 1984). The goal of the taxonomy was "to define the fewest independent ability categories which might be most useful and meaningful in describing performance in the widest variety of tasks" (Fleishman, 1967, p. 352). The taxonomy included two broad categories of abilities related to motor performance: *perceptual motor abilities and physical proficiency abilities.* Table 3.3 presents and defines the eleven perceptual motor ability categories Fleishman

TABLE 3.3 Perceptual Motor Ability Categories Identified by Fleishman (1972) as a Result of Numerous Research Studies

Ability Category	Definition	Ability Category Test and Related Motor Skill Example
Multilimb coordination	Ability to coordinate movements of a number of limbs simultaneously	*Complex coordinator task:* Person simultaneously controls two levers, one with each hand, and two pedals, one with each foot, in response to signals *Skill example:* Playing the piano or organ, where both hands and feet are involved
Control precision	Ability to make rapid and precise movement adjustments of control devices involving single arm-hand or leg movements; adjustments are made to visual stimuli	*Rotary pursuit task:* Person keeps a handheld stylus in contact with a small disk embedded in a phonograph-like turntable as it rotates at 60 rpm *Skill example:* Operating a joy stick in a computer video game
Response orientation	Ability to make a rapid selection of controls to be moved or the direction to move them in	*Visual discrimination tasks, e.g., choice reaction time task:* Person responds as quickly as possible when one of several visual signals illuminates *Skill example:* Soccer player with the ball responding to defensive player's movements by dribbling past the player, passing, or making a shot at the goal
Reaction time	Ability to respond rapidly to a signal when it appears	*Visual or auditory simple reaction time task:* Person responds as quickly as possible to a visual (e.g., a light) or auditory (e.g., a buzzer) signal *Skill example:* Start of a sprint in swimming
Speed of arm movement	Ability to rapidly make a gross, discrete arm movement where accuracy is minimized	*Two-plate reciprocal tapping task:* Person moves a handheld stylus back and forth between two metal plates, 25 cm apart, as rapidly as possible for 10 sec *Skill example:* Throwing a ball for speed rather than for accuracy
Rate control	Ability to time continuous anticipatory movement adjustments in response to speed and/or direction changes of a continuously moving target or object	*Pursuit tracking task:* Person moves a computer mouse to move a cursor on a computer monitor to maintain contact with a target cursor that changes in speed and direction *Skill example:* Driving a car on a highway
Manual dexterity	Ability to make skillful arm-hand movements to manipulate fairly large objects under speeded conditions	*Minnesota manual dexterity task:* Person picks up with one hand and turns over as quickly as possible a series of wooden pegs in holes *Skill example:* Dribbling and maintaining control of a basketball while running
Finger dexterity	Ability to make skillful, controlled manipulations of tiny objects involving primarily the fingers	*Purdue Pegboard task:* Person picks up and assembles small peg, washer, and collar units and inserts them into small holes *Skill example:* Buttoning a shirt

TABLE 3.3 (*Continued*)

Ability Category	Definition	Ability Category Test and Related Motor Skill Example
Arm-hand steadiness	Ability to make precise arm-hand positioning movements where strength and speed are minimized; includes maintaining arm-hand steadiness during arm movement or in a static arm position	*Track tracing task:* Person moves a handheld stylus through a trough in a board without touching the sides of the trough; and *Hand-steadiness task:* Person holds a stylus in a small hole without touching the sides of the hole *Skill example:* Applying eyeliner
Wrist, finger speed	Ability to make rapid and repetitive movements with the hand and fingers, and/or rotary wrist movements when accuracy is not critical	*Tapping task:* Person holds a pencil and taps its point as many times as possible in a large circle for a specified amount of time *Skill example:* Handwriting for speed
Aiming	Ability to rapidly and accurately move the hand to a small target	*Manual aiming task:* Person holds a pencil and rapidly makes a dot in a series of very small circles *Skill example:* A drummer rapidly moving a stick from a snare drum to a small cymbal

Note: The ability labels, definitions, and tests are as Fleishman presented them in two reports on his work (Fleishman, 1972, p. 1019; Fleishman & Quaintance, 1984, p. 164).

proposed. Note that table 3.3 also includes an example of one of the tests he used to assess each ability and an example of a motor skill whose performance would be associated with the ability category.

In addition to perceptual motor abilities, Fleishman also identified nine abilities that he designated as *physical proficiency abilities.* These abilities differ from the perceptual motor abilities in that they are more generally related to gross motor skill performance, which most people would consider as physical fitness abilities. The physical proficiency abilities identified by Fleishman are as follows: (1) *static strength,* the maximum force that a person can exert against external objects; (2) *dynamic strength,* the muscular endurance used in exerting force repeatedly; (3) *explosive strength,* the ability to mobilize energy effectively for bursts of muscular effort; (4) *trunk strength,* the strength of the trunk muscles; (5) *extent flexibility,* the ability to flex or stretch the trunk and back muscles; (6) *dynamic flexibility,* the ability to make repeated, rapid trunk-flexing movements; (7) *gross body coordination,* the ability to coordinate the action of several parts of the body while the body is in motion; (8) *gross body equilibrium,* the ability to maintain balance without visual cues; and (9) *stamina,* the capacity to sustain maximum effort requiring cardiovascular effort.

We should not consider Fleishman's lists to be exhaustive inventories of all the abilities related to motor skill performance, because Fleishman wanted to identify the smallest number of abilities that would describe the tasks performed in the test battery. Although he used hundreds of tasks to identify those abilities, the inclusion of additional types of tasks besides those Fleishman used could lead to the identification of other motor abilities. For example, Fleishman did not include the following abilities in his two lists:

- *Static balance*—The ability to maintain postural stability on a stable surface or when not engaging in locomotor activities (e.g., standing on the floor while reading a book)

A CLOSER LOOK

The Relationship between Perceptual Motor Abilities and Handwriting Speed: Implications for Occupational Therapists' Interventions

Slow handwriting speed can affect children's school performance by preventing them from completing handwritten work that must meet time constraints. To investigate factors that are associated with slow handwriting, Tseng and Chow (2000) administered three perceptual or motor abilities tests and a vigilance test to 7- to 11-year-old Chinese schoolchildren whose handwriting was slow or at normal speed.

Handwriting speed: The amount of time required for the children to copy in pencil a previously studied text (speed = the number of Chinese characters written per minute).

The abilities tests measured:
- arm movement speed and hand dexterity
- nonmotor visual perception (including discrimination, sequential memory, figure closure, etc.)
- visual-motor integration (which required the copying in sequence of a set of geometric forms)
- focusing and maintaining attention over time

Results: The following abilities were predictors of slow handwriting:
- arm speed and hand dexterity
- focusing and maintaining attention
- visual memory
- visual-motor integration
- visual sequential memory

Authors' conclusion: These results suggest that "intervention for slow handwriting should focus on facilitating visual processing, including memory and visual-motor integration, rather than the fine motor training so often emphasized in occupational therapy programs" (p. 87).

- *Dynamic balance*—The ability to maintain postural stability on a moving surface or when engaging in locomotor activities (e.g., walking on a sidewalk)
- *Visual acuity*—The ability to see clearly and precisely (e.g., reading a street sign)
- *Visual tracking*—The ability to visually follow a moving object (e.g., watching the flight of a ball that is thrown to you to catch)
- *Eye-hand or eye-foot coordination*—The ability to perform skills requiring vision and the precise use of the hands (e.g., correctly typing a sentence on a keyboard) or feet (e.g., kicking a penalty kick in soccer)

An important assumption of this view of human abilities is that all individuals possess these motor abilities. Another is that because it is possible to measure these motor abilities, it is also possible to determine a quantified measure of the level of each ability in a person. People differ in the amount of each ability they possess. Their motor abilities indicate limits that influence a person's potential for achievement in motor skill performance.

Relating Motor Abilities to Motor Skill Performance

Figure 3.2 illustrates the view that motor abilities are underlying, foundational components of motor skill performance. This figure shows how we can analyze complex motor skills by a process known as *task analysis* in order to identify the abilities that underlie any motor skill. For example, to serve a tennis ball successfully, a player must perform certain components of that skill properly. Figure 3.2 identifies these components, which are the first level of analysis of the tennis serve, in the middle tier of the diagram. Identification of these components helps us identify more readily the underlying motor abilities that are involved in

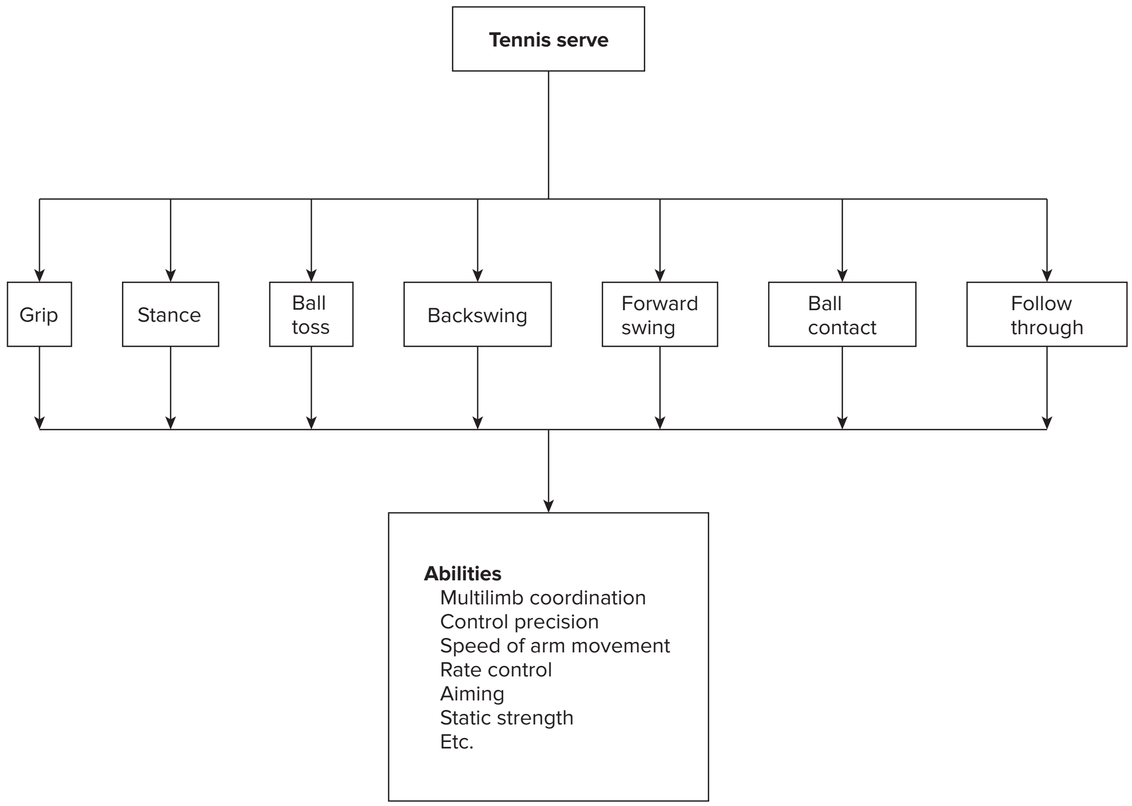

FIGURE 3.2 A task analysis for the tennis serve indicating the component parts of the serve and some examples of perceptual motor abilities underlying performance of the serve.

the successful performance of this task. The bottom tier of the diagram presents these abilities. Based on Fleishman's lists, they include such abilities as multilimb coordination, control precision, speed of arm movement, rate control, aiming, and static strength. You undoubtedly could add others. However, these few examples should serve to illustrate the foundational role perceptual motor and physical proficiency abilities play in the performance of motor skills.

Uses for tests of motor abilities. Because of the foundational role played by motor abilities in the performance of motor skills, tests of motor abilities are used for a variety of purposes. We will consider two of the most common. One use is the *prediction* of future performance of a motor skill or physical activity. Tests used for this purpose are sometimes called aptitude tests. For example, the military and industry use tests of motor abilities in their batteries of tests to select people to train for or work in specific jobs (e.g., Chan, 2005). Medical and dental schools often include motor abilities tests in their selection of students for specialist training or admission into specific programs. And professional sports teams, and national and international sports agencies, typically give motor abilities tests as part of test batteries to select athletes for their teams.[3]

[3]For an excellent summary of the use of test batteries to identify future successful athletes in specific sports, read the Introduction of the article by Vandorpe et al. (2012).

A CLOSER LOOK

The Assessment of Motor Abilities as Part of the Complex Process of "Talent Identification" in Sports: An Example from Gymnastics

In Belgium, the Flemish Gymnastics Federation conducts an annual selection day to determine which 7- to 8-year-old female gymnasts will be chosen for the national talent development program to become an elite senior gymnast. In a research study reported by Barbara Vandorpe and colleagues at universities in Belgium (Vandorpe et al., 2012), 23 of the gymnasts were assessed with a multidimensional test battery, with its results compared to the gymnasts, all-around competition results two years later, when the gymnasts were classified as either elite or subelite.

Assessment

Included in the selection process was a multidimensional test battery that included an assessment of motor coordination, which is a non-gymnastics-specific test that includes the following four subtests:

1. Walking backward on balance beams of different widths
2. Moving sideways on wooden platforms for 20 sec
3. Jumping sideways with two feet over a wooden slat for 15 sec
4. Hopping on one leg over foam obstacles of different heights

The performance scores were transformed into one score for each gymnast, which the test reports as an index of a child's motor coordination. In addition, the test battery also included nine basic motor skills tests: running backwards, skipping, hopping, shuffle pass, cross steps, bouncing, jumping jacks, tuck jumps, and giant jumps. Also assessed were specific physical characteristics of the gymnasts. Finally, expert coaches evaluated their technical skills.

Results

When these test results were compared to the outcome performances of the gymnasts at a competition two years later, the only meaningful predictor of competition result was the motor coordination score for the elite gymnasts; none of the initial test battery predicted competition outcomes for the gymnasts who were placed in the subelite category. Interestingly, the coaches' evaluations were not significant predictors of performance for either the elite or non-elite gymnasts.

Conclusion

This study serves as an excellent example of how difficult it is to identify the critical factors that would predict performance two years into a young athlete's future.

A second use of motor abilities tests is *evaluation,* which may include the evaluation of the causes of motor skill performance deficiencies or the assessment of the effectiveness of an intervention program, such as in physical rehabilitation. For example, therapists and athletic trainers use motor abilities tests to assess patients' rehabilitation progress and determine the types of functional activities the patient may be ready to undertake. Another common evaluation use of motor abilities tests involves the assessment of motor development in infants and young children. For both prediction and evaluation uses of motor abilities tests, the key to success is the development and use of valid and reliable tests.

SUMMARY

- The term *ability* refers to a general trait or capacity of the individual that is related to the performance and performance potential of a variety of skills or tasks. A variety of motor abilities underlie the performance of a motor skill; people have different amounts, or quantities, of these abilities.
- Historically researchers have proposed two hypotheses to describe how the various motor abilities relate to one another. The *general motor ability hypothesis* states that the abilities are highly related; the *specificity hypothesis* argues that the

abilities are relatively independent of one another. Research evidence has consistently supported the specificity hypothesis.

- There has been some debate among those who hold the specificity hypothesis concerning the generality of certain specific motor abilities, such as balance and timing. Research indicates that *balance* consists of static and dynamic balance as two relatively independent motor abilities and that several relatively independent variations of each exist. *Timing ability,* which refers to the precise timing involved in performing motor skills, is specific to the requirements of the task being performed.

- An important contribution to the identification of motor abilities was Fleishman's taxonomy of perceptual motor and physical proficiency abilities. The abilities identified in this taxonomy, along with others not included, play a foundational role in the performance of motor skills. Research shows that people differ in their amounts of each ability. These levels indicate limits that influence a person's potential for achievement in specific motor skills.

- Tests of motor abilities are typically used to predict future performance of a specific activity and to evaluate the possible causes of motor skill performance deficiencies or the effectiveness of an intervention. For either purpose, the key to success is the development and use of valid and reliable tests.

POINTS FOR THE PRACTITIONER

- Because of the specificity of motor abilities, students should not be classified according to motor ability categories that indicate amounts of motor ability.

- The identification and assessment of specific motor abilities can provide you insight into possible reasons for a person's difficulty performing or learning a motor skill. For example, a physical education student may have difficulty catching a thrown ball because of a poorly developed ability to visually track a moving object.

- Because certain motor abilities underlie the successful performance of various motor skills, you can develop physical activities to improve performance in a variety of skills that involve the same foundational motor ability. For example, various activities that require hand-eye coordination can serve as a unit of instruction in physical education.

- Evaluation of motor skill performance deficits should be skill specific. For example, the assessment of balance problems should be specific to the type of balance required by a skill of interest. Similarly, the assessment of locomotor movement problems should be specific to the types of gait of interest.

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STUDY QUESTIONS

1. (a) How do people who study individual differences define the term *abilities?* (b) Distinguish the meaning of *abilities* from that of the term *skill.*
2. (a) What is the difference between the general motor ability hypothesis and the specificity of motor abilities hypothesis? (b) Give an example of research evidence indicating which of these hypotheses is more valid.
3. How is balance an example of a motor ability that includes at least two types of relatively independent variations?
4. How can a specificity view of motor abilities explain how a person can be very successful at performing a lot of different motor skills?
5. (a) Name and describe five perceptual motor abilities identified by Fleishman. (b) What other motor abilities can you identify?
6. Describe how the assessment of motor abilities can be used in a battery of tests designed to identify people who would be good candidates for jobs or professions that require specific motor skills.

Specific Application Problem:

(a) You are working in your chosen profession. Describe a motor skill that a person you are working with is having difficulty performing.

(b) Describe how you would determine whether the reason for the difficulty is related to a motor ability problem or to some other reason, such as lack of practice, poor instruction, and the like.