CHAPTER 12

Movement Intelligence: A Vast Store of Motor Programs

After completing this chapter you should be able to:

- explain the concept of movement intelligence in motor skill development;
- describe the rationale for and characteristics of motor programs and movement abilities, and give examples of each;
- discuss the relationship between motor abilities, motor programs, and skills;
- define motor skills and describe their characteristics;
- apply knowledge of the characteristics of a skill to analyze movement;
- explain classification of skills and demonstrate an ability to design learning progression for an open skill.

Whatever activity we may be engaged in, the ability to perform certain skills will always have a bearing on how the activity eventually turns out. Watching others perform skills, and doing so ourselves in various contexts, is a significant part of our lives. During the Winter and Summer Olympic Games and other sporting spectacles, our eyes are glued to the television as we watch, in awe, players and athletes demonstrate an unbelievable level and range of skill. We watch them believing that perhaps we might attain a fraction of their skill, but also so we can share their experiences, if only for a moment.

While Olympic and professional athletes have attained a level of achievement in athletics that most of us will probably never reach, we are all capable of performing the same motor skills they do to one degree or another (Figure 12.1). But many factors will have a significant impact on our ability to execute these skills. All skills share some common characteristics, but they also possess some unique differences that influence learning and performance.

It is no mystery that human skills take many forms. Indeed, the remarkable number of skills we perform is an integral part of not only physical activity and sport but also our daily lives. But the term "skill" is open to several interpretations. We see swimmers execute flip turns at the wall, track athletes clear hurdles with remarkable precision, basketball players shoot jump shots from various positions on the floor, and soccer players head the ball with amazing control. But what are the elements common to these skills? How are skills classified? And what factors affect the learning and execution of these skills? These questions will now be considered in greater detail.

Figure 12.1 In order to attain a high level of achievement in physical activity and sport later in life, it is important to develop a vast repertoire of movement experiences early in life.

Movement Intelligence

Movement intelligence is an aggregate and vast repertoire of movement experiences developed since birth.

We possess the capacity to produce a seemingly endless variety of skills that are inextricably woven into the fabric of our lives. Numerous skills enable us to complete the daily tasks involved with work and school, as well as to participate in many physical activities, all of which offer different and unique challenges. The skills we possess are by no means static elements of our lives; they are continually being enhanced, revised, and adapted through experiences. The ability to learn new skills allows us to improve the way we live in striking ways.

Unlocking Your Potential

Today, we often hear about the many benefits to be had from active living, regular exercise, and a healthy lifestyle. But the advantages of any physical activity depend on some degree of movement intelligence. Participating in activities at an intensity and duration that have a positive impact on our health is greatly enhanced by having a developed skill level. While the advantages offered by physical exercise seem obvious, many individuals may feel uninspired to follow an active lifestyle because they believe their options are limited. Activities such as walking, running, and cycling are undoubtedly effective for improving one's level of fitness, but how attractive are they to the average person? Some might prefer to take part in other nonphysical activities that arouse their interest and that are more fun and enjoyable.

The development of diverse skills can help greatly in this respect. A grasp of the specific skills involved in the activities you would like to pursue will broaden your options, and the possibilities will begin to seem endless. Rather than using the excuse that walking and running are dull and monotonous, you can get out onto the tennis court or take part in a beach volleyball game (or whatever activity you enjoy), displaying your enhanced level of skill with renewed interest and confidence. Being skillful means getting out of physical activity all there is to gain – health, fun, and vitality.

Motor Programs

When learning new skills, we develop movement plans that are eventually stored in memory, known as **motor programs (MPs)**. It is hypothesized that repetitive practice encourages the formation of specialized nerve circuits in the central nervous system that work together when developing a plan for an activity or skill (for more on this topic see Chapter 11). Thus, motor programs emerge as a result of learning.

Motor programs are a set of prestructured muscle commands that, when well developed, allow the performer to carry out the skill automatically. Many skills and movement patterns that must be carried out quickly, almost reflexively, serve as strong evidence for the concept of motor programs. Motor programs also help explain the performances of figure skaters, gymnasts, dancers, and pianists, who must quickly combine together a series of discrete movements into a lengthy program.

Generalized Motor Programs

It is quite possible that developing and storing motor programs for every conceivable movement would place too great a demand on memory. How then do we explain the ability of a performer to meet the ever-changing demands of environmental conditions? In sports, the situations that arise during training and competition and the appropriate actions (motor programs) that must be taken are never exactly the same. In table tennis, for example, every forehand the player hits differs from the one that preceded it. How many motor programs, then, are really needed for the great variety of strokes a table tennis player makes during a rally?

Motor learning scientists have suggested a **generalized** or **dynamic motor program (GMP)**, an alternative to the simple motor program just discussed. The generalized motor program still consists of a stored pattern of movements, but its actual structure is conceived as more abstract. Central to this more general concept is the existence of **parameters**. Some of these parameters are stable and others are more unstable, or changing, depending on the situation in the environment. Parameters specify such things as the order of events or subroutines (see Figures 12.7 and 12.8 for examples of skill hierarchies), the overall duration of the movement, the overall force needed to accomplish the movement, the temporal patterning (explained later in this chapter), and the spatial and temporal order in which the components of the movement are to be executed (explained later in this chapter). An example of a generalized motor program's characteristics and its actions is provided in the box *Table Tennis Forehand in Action*.

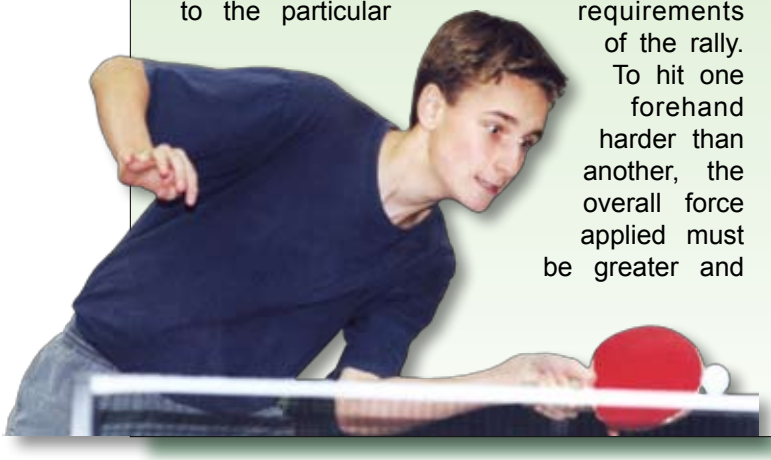
When generalized motor programs become well established, they form the basis for automatic and spontaneous movements in sports. They ensure that the athlete's movements, even under different conditions, become supple and adaptable. Well-established generalized motor programs require little or no attention or mental effort, and with experience, their execution becomes fully automatic. A theoretical discussion of this topic is beyond the scope of this textbook.

Movement Intelligence and Motor Programs

Movement intelligence does not refer to any specific ability an individual may inherit. Rather, it is a term that can be used to explain proficiency in performing various skills. Movement intelligence is viewed simply as a vast store or library of motor programs. Like a store or library holding thousands of CDs, each containing numerous tracks, our movement intelligence store is a collection of numerous motor programs, some simple or complex, others fundamental or specialized.

Table Tennis Forehand in Action

The order of events in a table tennis player's forehand serves as an example of a **stable parameter** in the generalized motor program underpinning the stroke. Relative time and relative force to be applied in each stroke are considered stable parameters as well. Both, however, may also have **unstable characteristics** that are easily changed from one stroke to another. These characteristics can be readily adapted to the particular requirements of the rally. To hit one forehand harder than another, the overall force applied must be greater and the overall time taken to carry out the stroke must be faster. Speeding up the sequence of the movements (or subroutines) and increasing the overall force can seemingly be done without altering the stable characteristics of the generalized motor program controlling the player's forehand strokes. The parameters are applied to the generalized motor program in order to specify how a particular forehand is to be expressed.



A generalized motor program responsible for the table tennis player's forehand can then be used to perform a large number of similar and yet slightly different forehands by simply adding the appropriate set of movement parameters to the abstract plan of action stored in memory. Armed with a well-developed generalized motor program, the player is ready for the challenges that await him or her during a rally. The execution of forehand strokes becomes fluid and effective under most varied external conditions generated by an opponent.

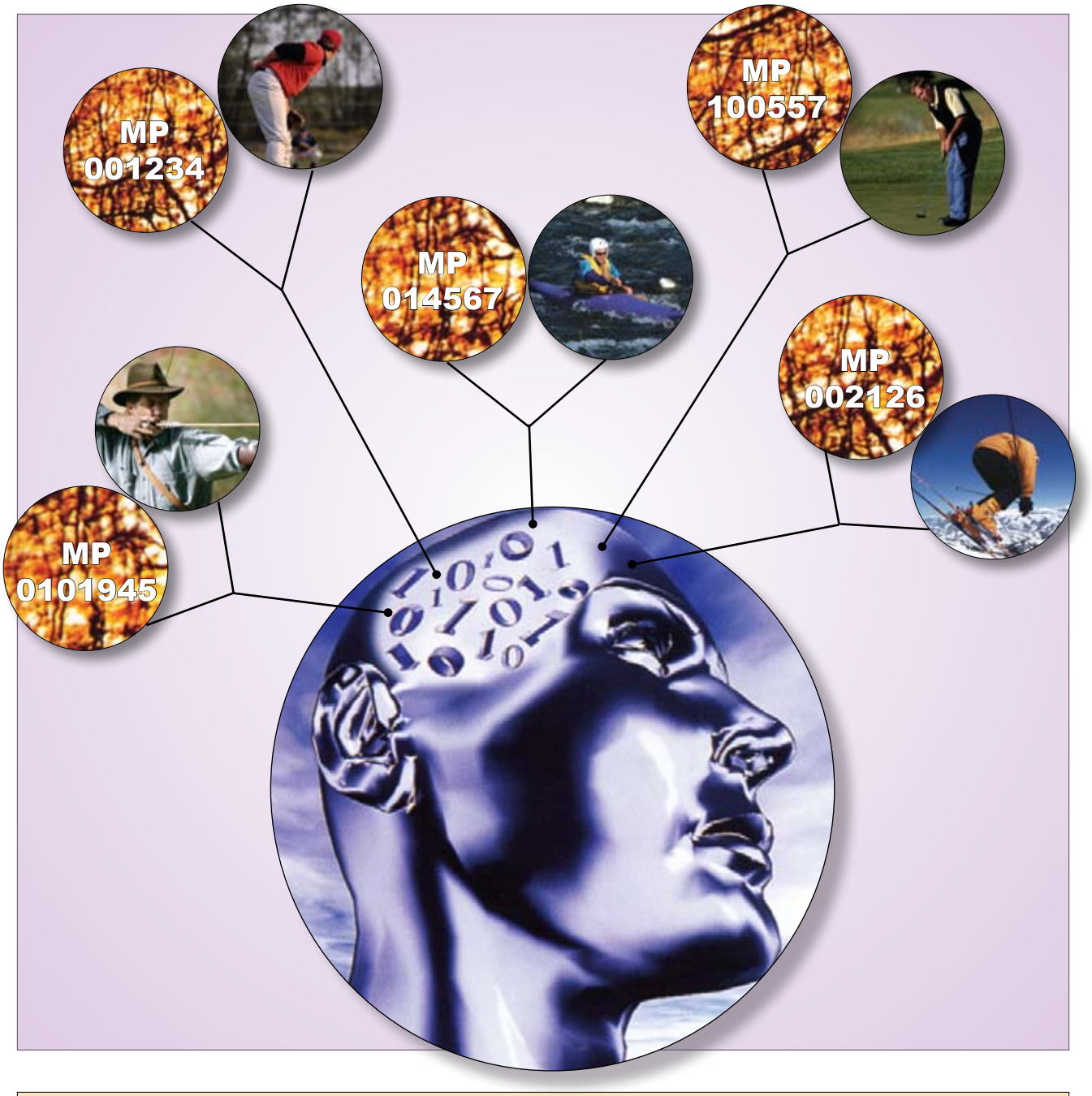


Figure 12.2 Hypothetical example of coded motor programs (MPs) assembled in an individual's motor memory, movement intelligence. Will we ever know how the human brain codes and stores MPs, the blueprints of skills?

Just as you cannot distinguish individual tracks on a CD until it is placed in a CD player, the motor programs stored in our memory through learning cannot be observed directly. But motor programs can be inferred by observing the skills and movement patterns we are capable of performing. In this sense, motor programs can be regarded as the blueprints of the skills we perform. They represent one side of a coin; skills represent the other. Skills are the observable side of the coin; they represent the movements we perform at the swimming pool, on the basketball court, or on the soccer field (Figure 12.2).

Obviously, the number of CDs matters as well.

Greater selection usually makes a larger collection better than a smaller one. Similarly, the degree of motor intelligence you possess has a direct bearing on participation in sports. The larger and more sophisticated your movement intelligence, the more proficient you will be in playing sports at recreational or competitive levels.

It follows that movement intelligence is an active and ongoing process that, through practice, helps individuals develop new specialized movement patterns that will help them adapt to ever more demanding situations in any athletic or recreational environment. Many factors affect the development of movement intelligence.

Factors Affecting Movement Intelligence

The development of movement intelligence depends upon many factors. They include adequate stimulation starting at an early age, opportunities for practice and continuous encouragement, following the right learning progression, expert instruction throughout educational programs, opportunities for practice in community clubs, and the use of quality equipment. However, one factor remains vital for the development of movement intelligence: the inheritance of abilities. In the next section we will look briefly at the question of abilities and their implications for developing movement intelligence.

Movement Abilities

In previous sections we established that motor programs, the blueprints of skills, are active nervous circuits entrenched in the brain and stored in memory. The quality and the effectiveness of these motor programs depend on the presence of underlying motor abilities. In this context **motor or movement abilities** are considered inherited, relatively enduring, and stable traits that serve as the foundation for the development of motor programs. They are the "hardware" that learners bring with them to the learning environment.

For example, balance, speed of reaction, and finger and wrist dexterity are examples of abilities that are important for the development of a variety of motor programs that are outwardly manifested in a badminton smash, a sculling stroke, or a hockey slap shot (Figure 12.3).

A workbench analogy may help in understand-

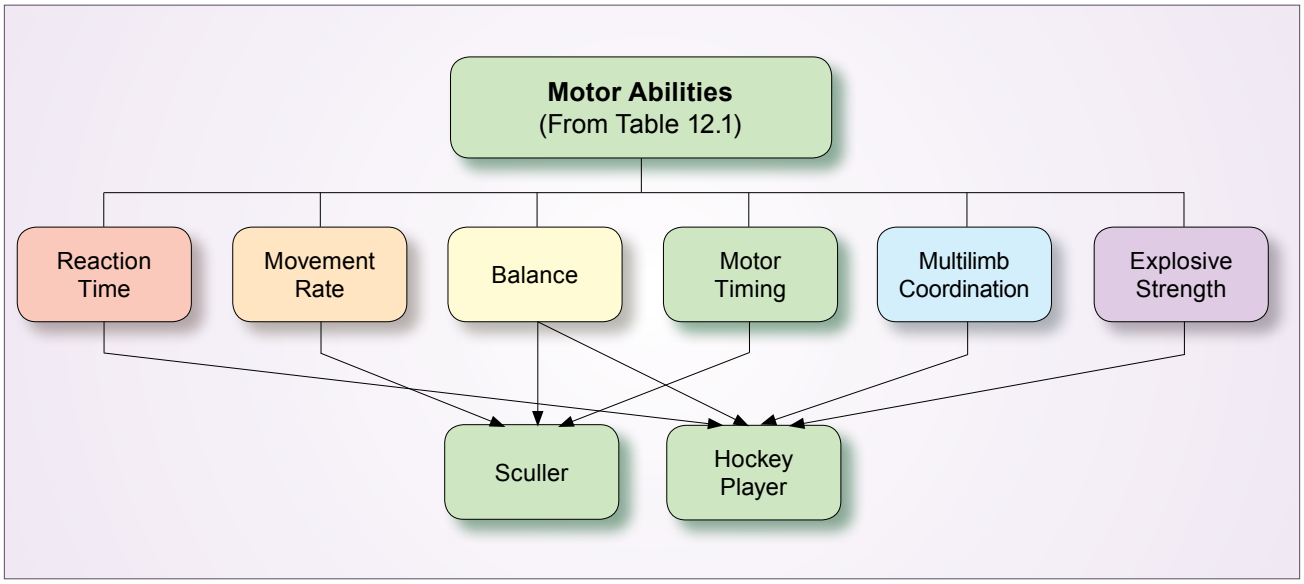


Figure 12.3 Hypothetical model of links indicating abilities underlying performance in two skills, rowing and hockey.

ing the relationship between motor abilities and skills. Motor abilities can be regarded as tools of various kinds used by the carpenter. To build a particular item, such as a table, the carpenter uses several different sets of tools that are highly specialized for cutting, filing, holding in place, drilling, and so on. However, different sets of tools are used for building a shelf. Similarly, the inherited movement abilities are the "tools" used in a variety of combinations to develop and perform skills (Figure 12.3).

Human Abilities Questions and Answers

How many abilities are there?

Relatively limited motor learning research has revealed 26 abilities that have been classified into three major categories as shown in Table 12.1. The first category of abilities deals with **perceptual motor abilities**, such as reaction time, dexterity, speed of movement, and coordination. The second category of abilities is related to human **physical proficiency**, such as flexibility, strength, endurance, and balance. The **general coordination abilities** in the third category deal with control of timing, rate of movement, and control of muscle force.

The search for human abilities is far from over. Practice has shown that there may be more abilities than have been identified by laboratory research to date, ranging from visual skills and kinesthetic sensitivity to body configuration. It is expected that future research will identify new abilities that could better explain sport performances of various kinds.

How many abilities do we have?

It is assumed that all individuals possess all of the abilities listed in Table 12.1, albeit to varying degrees. In other words, people differ in the amount or the strength of each ability. For this reason, abilities (or lack thereof) impose limits that influence an individual's potential for success in performing certain skills.

Furthermore, no two individuals have exactly the same pattern of motor abilities. This also explains individual differences in the quality of performance on movement tasks.

Why do people excel at some activities and do poorly in others?

This depends upon the strengths and weaknesses of one's inherited motor abilities (Figure 12.4). A champion sculler, for example, would possess inherited strengths in the particular abilities relevant to sculling (balance, movement rate, motor timing). If the abilities required to play hockey (explosive strength, multilimb coordination) were relatively weak, the same individual would not necessarily excel in hockey and may therefore exhibit less skill as a hockey player (Figure 12.3).

Who are the all-around athletes?

From experience we know there are individuals who perform well in several sports. Because many fundamental abilities are likely common across a variety of sports (balance in Figure 12.3), it is reasonable to assume that **all-around athletes** possess strong abilities that underlie the many sports in which they excel. These athletes differ from the average individuals in the number of abilities in which they are superior. As a result, there are more activities (ball sports, racket sports, contact sports) in which these individuals can achieve success.

Can practice improve motor abilities?

We have stated that human abilities are genetically determined and relatively stable. However, many teachers and coaches believe, based on long-term experience, that intensive ability-specific practice may potentially improve motor abilities. For example, coaches use countless speed drills to enhance the reaction time and agility in players; circus performers practice diligently on various types of swaying equipment to develop better balance; gymnasts improve their dynamic and extent flexibility through range-of-motion-specific practice.

Table 12.1 Human abilities as identified by motor learning research.

A. Perceptual Motor Abilities	**Examples of Skill**
Control Precision: Requires fine, highly controlled muscular adjustments, primarily in situations in which large muscle groups are involved. This ability extends to arm–hand as well as to leg movements.	• Forklift operators who are required to maneuver with careful positioning of the arms and feet.
Multilimb Coordination: The ability to coordinate a number of limb movements simultaneously.	• Batting in baseball, shooting in hockey, or hitting in volleyball.
Response Orientation: Involves quick choices among numerous alternative movements, more-or-less as in choice reaction time.	• Task facing a goalie in soccer, where the type and direction of a shot on goal is uncertain.
Reaction Time: The speed with which a person is able to respond to a stimulus when it appears.	• Starting off the mark quickly in swimming, sprinting, or speedskating.
Speed of Arm Movement: The speed with which a person can make large, discrete arm movements in which accuracy is not the requirement.	• Throwing a shot for maximum distance.
Rate Control: Involves making continuous anticipatory motor adjustments relative to changes in speed and direction of a continuous moving target or object.	• Skiing, snowboarding, or white-water canoeing.
Manual Dexterity: Demonstrated by skillful, well-directed arm–hand movements in manipulating fairly large objects at various speeds.	• Dribbling a basketball or setting in volleyball.
Finger Dexterity: Involves making still-controlled manipulations of small objects involving, primarily, the fingers.	• Threading a needle or assembling parts of a small object.
Arm–Hand Steadiness: The ability to make precise arm–hand positioning movements where strength and speed are minimized.	• Archery and pistol shooting.
Wrist–Finger Speed: Involves the rapid movement of the wrist and fingers, with little or no demand for accuracy.	• Playing the bongo drums and a quick snap of the wrist during a badminton smash.
Aiming: Requires the production of accurate hand movements toward targets at various speeds.	• Throwing a horseshoe or hitting a target with the rapid throw of a dart.

B. Physical Proficiency Abilities	**Examples of Skill**
Explosive Strength: The ability to expend maximum energy in one or a series of explosive acts.	• Performing maximum vertical jumps in volleyball, basketball, or high jump.
Static Strength: The maximum force a person can exert for a brief period.	• Maximum lifts in weightlifting or moving a large object such as a refrigerator.

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