

Chapter 3

Skill acquisition and learning

The ability to learn a skill or technique is integral to athlete development and is therefore a component which needs to be addressed by the coach and athlete throughout all stages of the development process. This chapter will introduce the process of skill acquisition and motor learning. Therefore upon completion of this chapter you will have:

- understood the term 'skill' and how this differs from 'ability';
- addressed the different types of skill and how these can be associated with different sports;
- explored models of skill acquisition and learning;
- examined the role of memory and memory processing in the acquisition and learning of skill;
- addressed the models related to motor learning;
- applied the models and theories to the role of the coach.

Introduction

Anyone who competes in sport at any level will be aware that an integral part of success in sport is derived from the level of possessed skill or proficiency. Athletes and coaches often describe the development of skill within the training process and overall growth of the athlete, implying that skill can be both innate and learnt. Furthermore, it is clear that different sports require different sets of skills, e.g. a sport such as rifle shooting requires proficiency in 'fine' motor skills, whereas cycling requires 'gross' motor skill proficiency.

What we need to consider is how athletes learn skills and why some naturally acquire skills more effectively than others. By understanding the nature of skill acquisition within sport we begin to address two major coaching concepts: (1) How to structure training sessions in order to optimise the development of the athlete; (2) The best way to teach the skill to an athlete.

I have pondered these tenets for sometime. As an athlete, I have been lucky enough to be good at any sport I tried (400m running, swimming, track cycling), yet when I decided to take up golf, I hit a hurdle – it did not come easy. I have consistently struggled to develop as a golfer despite practicing and playing on a regular basis, so why should this be? Why can I acquire the skills of some sports and not others? Through this chapter, we will explore the nature of skill and how we learn and develop as a performer.

From this starting point we will begin to better understand what differentiates elite and novice athletes.

What is skill?

When we start to consider skill as a concept and try to develop a consensus statement which caters for all sports and abilities, we are faced with a massive task.

Activity 3.1: What is skill?

Consider your own sport and create a list of the skills that contribute it. Then make a second list for a sport which is *completely* different, e.g. if your sport is soccer then perhaps a different sport would be synchronised swimming. For both sports, list skills that you consider pre-requisites to success in that sport. Once you have the two lists, consider the differences and similarities of both.

It is known that there are a set of physical traits which contribute to athletic performance, the so-called Ss of training (see Chapter 7): Speed, Strength, Stamina and Suppleness, and that each sport requires each of these fitness components in varying degrees. It is these basic fitness components that underscore our skill levels.

What distinguishes these Ss of training which we class as being skills from such traits as academic achievement and the ability or skill of learning? The answer lies in the prefix term that we apply in relation to sport, that of motor (skill). The term motor is used to categorise the movement of the body and limbs and so for the purposes of this chapter and your understanding, we will define motor skills as 'skills in which both the movement and the outcome of action are emphasised' (Newell 1991).

As all sporting events require the co-ordination of motor skills, it is perhaps not surprising that there are many classifications of skill which contribute to athletic performance. An overview of these skill classifications is presented in Table 3.1.

Table 3.1: Classification of skills

Skill type	Classification
Fine and gross skills	Motor skills can be subdivided into those skills which require co-ordinated sequencing of large muscle groups, e.g. for shot putting or triple jumping (gross skills) and those requiring more precise, controlled muscular movements and sequencing, such as archery and gymnastic events.
Open and closed skills	Skill can be classified by the degree to which the external environment affects the performance of the skill. In sports such as rifle shooting, archery and diving, the environment is highly predictable, therefore they are classified as closed skills in that they are discrete and have minimal external influences. Conversely, there are those skills which can be influenced quite considerably by external factors such as in team sports, racquet sports and the combat sports. These sports are classified as

Table 3.1: Continued

Skill type	Classification
	having an open skills base, as they are open to influences which are external to the athlete.
Skill cycles	Some skills have a very clear start and end point to their execution, such as in the golf swing or penalty stroke in hockey. Once they have been executed, the skill is complete and there is a clear end point, therefore we classify these as being discrete in nature. At the other end of the skill spectrum are those which have no clear start or end point, such as in running and swimming, where there is a cyclical nature to the skill, the distinction being that once the action is stopped, the movement is not rendered incomplete. Therefore these skills are classified as being continuous in nature. Many sports require a combination of both discrete and continuous skills, such as in sprinting where we can view the drive phase out of the blocks as a discrete skill and the acceleration and speed maintenance parts of the dash as continuous in nature.
Serial skills	Some skills do not conform to being either discrete or continuous, such as when a sequential series of different skills are performed to produce the overall action, such as in gymnastic events.
Skill pace	An action or skill that is under the control of the athlete is deemed to be internally controlled, such as pitching in baseball or a free throw in basketball. Those skills whose timings are affected by external conditions are referred to as being external skills, such as saving a penalty in soccer or returning a serve in tennis.

Activity 3.2: Classification of skill

Table 3.2 lists a series of sports or sporting actions. For each, identify the level of motor control and whether the skill is open or closed, the skill cycle and the pacing of the skill. Just tick the box(s) which best classify each action.

Table 3.2: Sports or sporting actions

Action	Skill classification								
	Fine	Gross	Open	Closed	Discrete	Continuous	Serial	Internal	External
Pitching									
Sprint start									
High dive									
Archery									
Canoe slalom									
Snooker									
Darts									

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Models of skill acquisition

When we study the literature relating to skills acquisition, it is possible to identify an evolution in the development of both understanding and construction of the proposed models and concepts. The model that has perhaps had the greatest influence on the study of skill acquisition is the Closed Loop theory of Adams (1971), which proposed that in order to learn a skill, two memory domains must exist.

The memory domains were separated by the distinction that one was associated with the initiation and implementation of the skill, while the other acted as the template or benchmark against which the actioned skill is compared. The former memory domain was termed the 'memory trace' and the size of this trace or file grew in proportion to the amount of time spent practicing the skill. The later memory domain was according to the model termed the 'perceptual trace' and its size was based on prior experiences in the form of both proprioceptive and exteroceptive actions. If you would like to gain a greater understanding of proprioception refer to the *Concept box* below.

Concept 3.1: Understanding proprioception

What is meant by the term proprioception?

This is a term used to describe a form of sensory information which relates to the position of the limbs and the body within time and space. In other words, proprioception information informs us through the central nervous system (CNS) what our muscles are doing during any action and how much tension is being applied through a muscle and our bodily orientation. Quite commonly, proprioception is referred to as kinesthetics, which is a term used to imply the same form of information.

How is this information derived?

Within the body there are many forms of receptors which provide the information regarding a specific limb or position. For example, within the muscle we have two forms of receptors: the Golgi tendon apparatus which senses the amount of force being applied through a muscle and the muscle spindles which inform us (through the CNS) about the changes in muscle length.

What is proprioceptive feedback?

Given that we now recognise what is meant by the term 'proprioception' the concept of proprioceptive feedback should be the next logical step. Imagine performing a somersault on a trampoline. You would initiate the movement generating tension in the muscles to swing the arms, creating a rotation in the body and attempting to land back on your feet. Throughout the whole movement you would be aware of your position within time and space. These processes and actions are centred on feedback loops: the action is performed; the position/tension, etc. are indicated; the information is interpreted in the brain and the information is then relayed back through the CNS to the requisite structures, whereupon the appropriate action is implemented. Therefore, there is generation of feedback to the information generated from the receptors.

How does this work in a sporting context? When the individual practices a skill, a series of sensory files are produced, very much like the way in which files are produced on a computer. This perceptual memory file is amended each time the skill is performed, but all actions are compared with the most up-to-date file. This is a fascinating model and one which received some attention in the mid- to late-1970s, but which finally became subsumed by a larger more robust theory of skill acquisition, namely Schema theory (Schmidt, 1975).

Schema theory extends the framework of Adams by still retaining the concepts of motor recall and recognition (Newell, 1991) but provided a link (schema) between these two areas. Consider the schema as being a master file which contains all of the necessary information required for completion of a movement as highlighted in Table 3.3. So as with Adam's theory when an action is performed, the movement is compared with the schema. Thus, the more a skill is practiced and feedback provided, the more both the recall and recognition schemas will develop.

So far, there would appear to be very little difference between Schema theory and the Closed Loop theory of Adams. However, on closer inspection, we note that there are two clear distinctions. The first is crucial in that unlike Closed Loop theory the model of Schmidt does not propose a feedback loop and is explicit in suggesting that feedback does not necessarily directly transfer from one schema to another, in other words recognition does not always provide feedback to recall. The second distinction is something that, as coaches, we witness in sport, the issue of transference. Schema theory suggests that skill is developed in relation to a movement rather than that movement in relation to one specific scenario. As such, Schema theory allows for the idea of transference of skill from one situation to another.

So why did Schema theory come about? According to Newell (1991) there were two reasons which prompted this change in thinking. First was the issue of novelty. How could a new skill be framed when in theory there would be no perceptual trace from which to draw comparisons? Second, and perhaps less of an issue, was that of storage. How many motor programs could be stored before the file became overloaded?

Table 3.3: Classification of information types according to the scheme theory

Information type	Clarification of the information
Environmental	The place and conditions in which the actions were performed, such as indoors or outdoors or in competition or training.
Body form	The position and shape of the body required for the action, encompassing the mechanical components of the movement, such as speed, direction and force.
Results	For any action to be performed there has to be an initiation followed by a response, the response is therefore the result of the action, so we need to recognise the results or response to various actions.
Sensory	The sensations associated with movement need to be recognized; we need to get a feel for the movement pattern.

Activity 3.3: Reflecting on skill

Think about a particular skill either from your own sport or from a skill-based sport, such as diving or cricket.

Why do athletes report that they are aware almost immediately during the performing of an action that it has not been executed correctly? HINT: think about the Closed Loop theory.

Some sports require extremely rapid motor skill and movement patterns. Consider if the Closed Loop theory would apply to these rapid-based programmes. HINT: think about the timeframes involved for both the skill and also the interpretation of the information.

Activity 3.4: Schema theory applied to sport

One of the main advantages of Schema theory is the universal application of a learnt skill. There are two tasks related to this topic:

1. Reflect on why this should be an advantage to the acquisition of skill when compared with the Closed Loop theory; think about issues of processing capacity and storage of information.
2. Think of a skill that can be learnt in one sport that can be applied to another and whether the athlete would need to re-learn the skill, or simply adapt the skill for the new circumstances.

Practice and mastery

It is the coach's responsibility to coach and develop the athlete ensuring that they acquire the skills and skill mastery as they progress. There are a myriad of methods that can be adopted as part of the coaching manual, which will help us in this process, as presented in Table 3.4.

For the coach, the key facet to this process is the degree of guidance and support that is provided to the athlete. There is little doubt that athletes who are supported and guided through their training prosper when compared with the non-guided athlete. The question however is, 'In what guise should the support come?'

The guidance given can be in the form of hands-on support: physically manipulating the athlete's body parts into the correct position during an action. We see this often used by tennis coaches where they stand behind the player and move the player's arm through the trajectory required for the swing.

A very common form of guidance is through the use of verbal support and instructions, where the coach explains what is required and the athlete follows these instructions when performing the skill. The final form of guidance is that of demonstration, which could simply be the coach demonstrating the skill through the use of video support and diagrams. This approach is used a lot in sports such as American Football when players needing to learn new skills can view video analysis from multiple

Table 3.4: Methods of practicing and developing a skill

Practice type	Method of practice
Mental rehearsal	In Chapter 6 we refer to the concept of mental rehearsal through imagery. This is a powerful tool but should not be used as the only means of developing a skill but rather in conjunction with the physical practice.
Whole practice	This is where the entirety of the skill is practiced. It is ideal for skills which are continuous in nature such as running and cycling.
Combined practice	A single skill is selected for the session but rather than being practiced for the entirety of the session it is combined with bouts of different activities. This is very useful with younger athletes and also where the skill, if repeated too often, could be associated with an overuse injury.
Mass practice	Under conditions of massed practice, the skill is rehearsed or practiced over a prolonged period of time (up to 3 hours) on a single skill, such as free kicks in soccer. Athletes tend to remember the skill through massed practice mainly because the process has been ground into them. This approach may prove to be problematic for younger athletes.
Part practice	Many of the serial skills benefit from being broken down into their constituent parts in order to master each sequence of the action. Part practice on its own, though, should be avoided as this may lead to disjointed and ill fitting skill patterns.
Physical practice	Practicing the skill through the recognised movement patterns is integral to the development of that skill as a whole.

angles. What is clear however, is that athletes benefit from a mix of all forms of guidance and that the coach should not rely solely on one approach; also we need to recognise what kind of learner the athlete is and take this into account when structuring the session (see Chapter 1).

Coupled with the ability to impart the requisite knowledge and instructions to the athlete, there is the need for appropriate feedback, which is discussed below.

At this point, we have managed to address what is meant by the term 'skill' and the variety of forms of skill that can be expressed by the athlete. We have also briefly examined different means of practicing and rehearsing these skills. However, in order to appreciate how skill is actually developed and improved upon, we need to address how skill is acquired, enhanced and expressed and this will become the focus of the following sections of this chapter.

Sporting ability

Skill proficiency is dependent on the ability of the individual. Ability therefore implies a restriction on the degree to which skill can be acquired within a sport, so highly able athletes are likely to acquire skill more effectively than those with lesser athletic abilities.

The nature of ability is important to our understanding of the processes of both long-term athlete development (Chapter 15) and talent identification (Chapter 14), because, e.g. an athlete with high cardiovascular fitness and speed but poor hand-eye coordination will probably not excel in rugby, but could be directed to endurance-based sports.

A word of caution however, for the implication here is that ability is in fact an innate factor dictating the degree of both achievement and development within a sporting pursuit. This is not entirely the case however, because the development of core athletic abilities of a given sport will, over time, allow for an enhanced capacity to acquire specific skill traits, thereby implying that abilities are trainable and not fixed.

Feedback and athlete support

All skill development requires feedback in order to allow for development of that skill. When we refer to the literature base it becomes apparent that there are many issues which relate to feedback, such as the timing, the form, the nature and its relationship to different skill sets and programmes (Schmidt and Wrisberg, 2000). From this information, we can observe that there are two very basic forms of feedback: that which comes from the athletes themselves and that which is derived from the coach and/or other observers. It is of course the latter that is affected by the coach.

Within coaching, we have to be effective at providing feedback to the athlete and in doing so recognise that there are two types of feedback: that which is performance-orientated and that which is outcome-directed. These forms of feedback are very much associated with the structures identified in Chapter 4 on goal setting.

Coaches need to make use of both forms of feedback to ensure that they communicate their message in a manner that is not perceived to be overly critical by the athlete, but at the same time not so diluted that the athlete fails to recognise which part of the skill was performed incorrectly.

Take home message

The learning and acquiring of skill is a process which needs to be nurtured by the coach allowing the athlete to develop at an optimal rate. We need to recognise however, that there are many forms of skill and that the ability of the athlete to acquire that skill is dependent not only on the stage of learning development, but also on the level of guidance and support provided by the coach.

Furthermore, although there are competing models of skill learning and acquisition, we should be aware of the common themes, such as the role of memory and information processing. Whichever school of thought you subscribe to, there is little doubt that

motor learning and development is an integral part of the development of an athlete and of the process of coaching and coach support.

Further study

The list below highlights a series of selected articles and books that will support your learning and understanding in relation to motor learning and development. As such, the list contains publications related to forms of feedback given to the athlete, the concept of innate talent and the principles of motor learning.

- Ericsson, K A, Krampre, R T and Tesch-Römer, C (1993) The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100: 363–406
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- Weeks, D L and Anderson, L P (2000) The interaction of observational learning with overt practice. Effects on motor skill learning. *Acta Psychologica Scandinavia*, 104: 259–70
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- Walf, G, Shea, C H and Matschiner, S (1998) Frequent feedback enhances complex motor skill learning. *Journal of Motor Behaviour*, 30: 180–92

- www.bases.org.uk/newsite/home.asp – British Association of Sport and Exercise Sciences: National body for sport and exercise science within the UK. Useful contacts and documents related to physiology, psychology, biomechanics, health and coaching.
- www.elitetrack.com/ – Elitetrack: A website which houses both peer reviewed and lay articles. All papers are referenced and are either written by coaches or sports scientists. A very good resource for all disciplines within coaching.
- www.eis2win.co.uk/gen/ – English Institute of Sport: National organisation whom support and work with elite athletes in England.
- www.everythingtrackandfield.com/catalog/matriarch/OnePiecePage.asp_Q_PageID_E_350_A_PageName_E_ArticlesGeneralCoaching – Everything Track and Field: Articles related to coaching and training.
- www.sirc.ca/ – SIRC: Sport, Research, Intelligence, Sportive: An international database which lists articles and publications related to coaching. Also has links to International Governing Bodies of Sport and Sport Institutes.