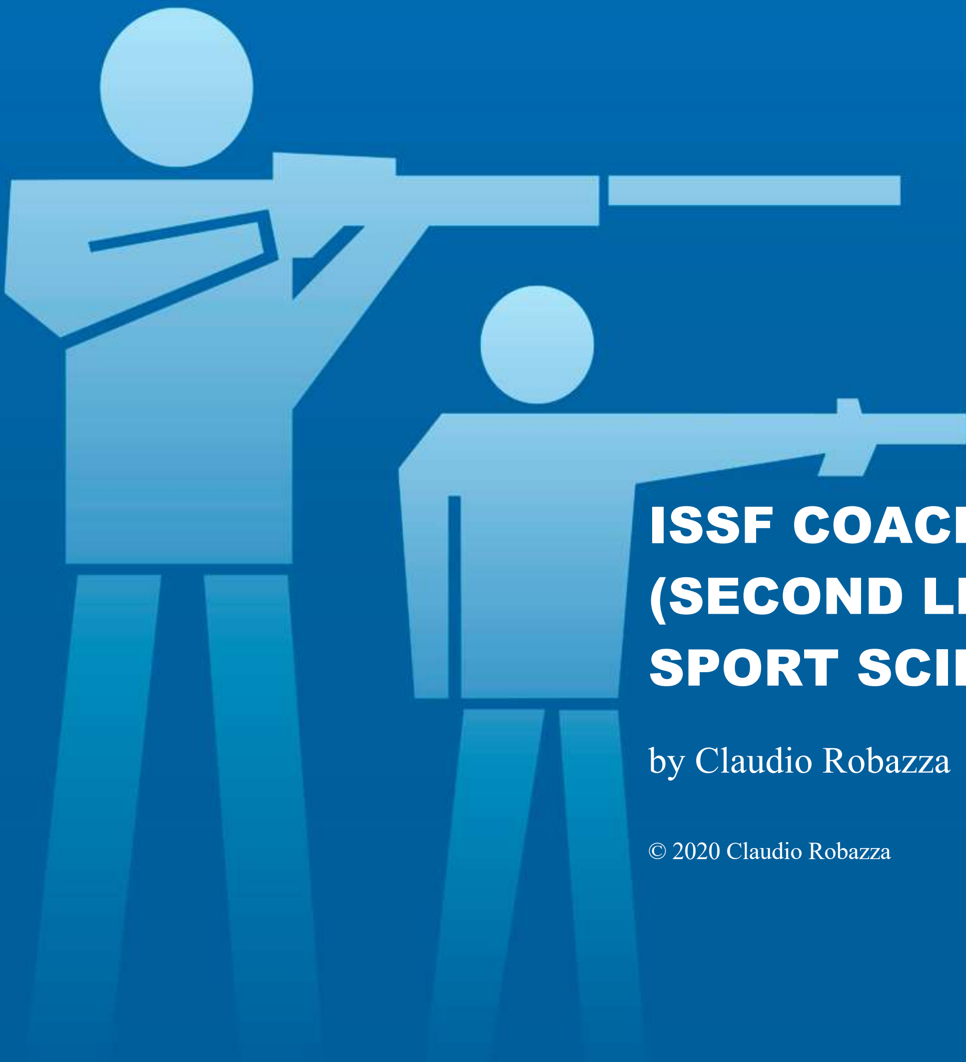

ISSF COACH (SECOND LEVEL) SPORT SCIENCE

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INTERNATIONAL SHOOTING SPORT FEDERATION

SPORT SCIENCE – ISSF COACH (SECOND LEVEL)

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INTRODUCTION

The Sport Science contents of this book are designed for the Coach (second level) course of the International Shooting Sport Federation (ISSF).

The presentation of this second level Course material builds upon the contents of the ISSF National Coach (first level) Course and assumes that those contents have been mastered and applied in the practical setting.

The Sport Science contents include four major areas of interest to coaches:

Chapter 1 – Motor skill learning. In this part we define motor skills and examine the stages that performers go through while they acquire new patterns of action. Coaches need to be knowledgeable about the learning stages, given that different instructional strategies must be applied in function of an individual's learning stage.

Chapter 2 – Scheduling practice for learning. After examining the characteristics of the stages of learning, the next step is to identify and implement effective teaching methods to allow people to improve their performance level and consistency over time. In this chapter we discuss a number of instructional strategies that complement those presented in the booklet for the ISSF National Coach (first level) Course (i.e., goal setting, instructions, demonstrations, and feedback).

Chapter 3 – Improving performance through mental practice. In this chapter we examine additional instructional and performance strategies that can be applied to improve and stabilise performance levels in practice and competition. A special emphasis is placed on mental practice (i.e., the mental rehearsal of actions) and on applied indications on how to make imagery most effective. A five-step strategy is also presented, which incorporates imagery into a performance routine.

Chapter 4 – Breathing and muscle tension/relaxation techniques for arousal self-regulation. In this final chapter, we examine the impact of arousal on performance and present bodily self-regulation techniques. Individual arousal is a mixture of general psychological and physiological activation that exerts functional or dysfunctional effects on performance. Arousal can be effectively regulated using breathing and muscle tension/relaxation.

As is the case for ISSF National Coach (first level) Course materials, the contents are presented in a concise and straightforward way. The interested reader who wish to deepen their knowledge in the areas of the Sport Science is referred to a number of references inserted at the end of each chapter. Coaches are strongly recommended to try not only to apply the many notions and recommendations reported here and in the literature, but also to develop their own strategies and coaching style.

CHAPTER 1 – MOTOR SKILL LEARNING

OVERVIEW

Beginners involved in the learning of a challenging new motor skill can feel frustrated in the first attempts when they fail. At first, individuals may struggle to understand what to do, how to coordinate limb movements, how fast the action should be, and how much force is needed. Initial attempts to deal with the motor task and find suitable solutions often result in awkward movements, tight muscles, stiff joints, confusion and, ultimately, poor performance. As practice continues, however, movements become smoother, more consistent and accurate, and individuals experience a growing sense of confidence as they become more successful.

In the following sections, we will examine the motor skills and the stages of learning that people go through in acquiring motor skills (for definition of terms, see Table 1.1). Effective coaches are able to identify the stages of skill learning and to tailor the instructional and practical experiences to meet the needs of learners in each stage. The ability of coaches to distinguish the stages through which people progress in the acquisition of motor skills is a requirement for the implementation of an effective learning environment.

Table 1.1. Definition of terms.

Terms	Definitions
Movements	Specific patterns of motion among joints and body segments used to accomplish action goals.
Motor abilities	Genetically determined potentialities of action that underlie the execution of movements and skilled performance. They are relatively stable and enduring characteristics genetically inherited. Abilities can be thought of as part of the basic "equipment" people inherit to perform various tasks in the real world. Examples are strength, speed, balance, reaction time, hand-eye coordination, and speed of limb movements. Note that the term ability is often used *incorrectly* to indicate motor skills.
Motor skills	Goal-directed activities or tasks that require voluntary control over movements of the joints and body segments to achieve predetermined results with maximum certainty, often with the minimum expenditure of time, energy or both. They are learned and improved by practice. Examples are the techniques of sport disciplines.
Motor learning	A set of internal processes associated with practice or experience leading to relatively permanent gains in the capability for skilled performance (i.e., an increased capability to produce motor skills). Examples of internal processes that change with learning are attention, memory, perception, and neuromuscular patterns of activation. Learning is inferred when performance: (a) increases over time through practice; (b) is more persistent, consistent, and stable despite challenging environments; and (c) is flexible to changing situations.
Motor control	The way the neuromuscular system works to activate and coordinate the muscles and limbs involved in performing a motor skill.
Skilled performance	Learned proficiency to achieve a desired outcome on a given task with maximum certainty (i.e., effectiveness) and efficiency—namely, a minimum expenditure of time, energy, or both.

MOTOR SKILLS

In the sport literature, a motor skill is understood as a complex act or task employed to achieve a specific goal and that requires the execution of voluntary movements. A motor skill is not only a reflex action, but involves part or whole body movements to be accomplished. The notion of 'skill' differs from the concept of 'ability'. Ability represents a potential for general motor behaviour, widely inherited and underlying skilful behaviour, in contrast to the more specific concept of 'skill'.

Almost all motor skills involve three main elements: (1) the cognitive component – deciding *what to do* to achieve the performance goal; (2) the perceptual component – deciding *where and when to do* the action in function of relevant environmental features; and (3) the movement component – deciding *how to do* the action (i.e., how to organise muscles activity to generate effective actions). Motor skills are therefore intertwined with cognitive and perceptual skills, which are necessary for the successful completion of the task.

Cognitive skills enable performers to know what to do and how to do it, while perceptual skills allow individuals to decide when and how to act. Examples of cognitive skills outside and within the motor domain include reading, writing, solving math problems, constructing persuasive arguments, memorizing strategies, and deciding tactical plays in soccer or other team sports. Perceptual skills involve the ability to detect information or to discriminate among sensory stimuli in the environment that are of primary importance for successfully carrying out the task. In clay shooting, for example, the sensory acuity of the shooters allows them to see the target in flight and its trajectory, thus allowing them to decide when to start the movement and where to shoot. Perceptual skills are so essential in accomplishing complex tasks that motor skills are often referred to as *perceptual-motor skills*.

Motor skills, therefore, are closely linked to the perceptual and cognitive components necessary for an accurate completion of the task. Along with perceptual and cognitive aspects, in shooting sports it is also the quality of the movement itself that is of paramount importance. For instance, a shooter may have no problem knowing what to do (aiming at the target) or understanding how to do it (taking the correct position, rising the arm, coordinating triggering and aiming, etc.). However, executing accurate and consistent movements to repeatedly hit the target remains a challenge.

Importantly, skills are learned. Motor skills embrace a wide range of behaviours performed primarily through the coordination of limbs and segments of the body. Individuals acquire a better capacity to achieve desired goals through experience or intentional practice. People are either unskilled or highly skilled at an activity, depending on their degree of learning rather than some underlying capacity or ability genetically acquired. Some skills, such as walking, running, and jumping, are learned in the early stages of development through interaction with the environment. Other skills, such as writing and reading, are learned through repeated and often unintentional practice. Finally, other skills are learned through intentional (deliberate) practice, as in the case of technical skills in sport.

CLASSIFICATION OF MOTOR SKILLS

Motor skills can be classified based on a limited number of common characteristics and relevant similarities. Table 1.2 summarizes the main characteristics of different types of motor skills.

Table 1.2. Different types of motor skills.

Motor skills	Characteristics
Gross	Motor skills that require the use of large muscle areas to achieve the goal of the skill.
Fine	Motor skills that require control of small muscles to achieve the goal of the skill. They generally involve eye-hand coordination and requires a high degree of precision in the movement of the hand and fingers.
Discrete	Motor skills with clearly defined starting and ending points of movement, which usually require simple movement.
Continuous	Motor skills with arbitrary start and end points of movement. These skills usually involve repetitive movements.
Serial	Motor skills involving a series of discrete skills.
Closed	Motor skills performed in a stationary or relatively stable and predictable environment, where the performer determines when to start the action.
Open	Motor skills performed in an unstable or relatively variable environment where changes in context determine the characteristics of the action (e.g., how, when, where to perform the action).

Common characteristics are classified along the two ends of a continuum rather than in dichotomous categories. This continuous approach allows a skill to be classified based on its main characteristics. Three classifications of motor skills frequently used include (1) the size of the primary muscle groups needed to perform the skill, (2) the temporal features of the skill relative to its beginning and ending, and (3) the stability of the environment in which the skill is performed. All motor skills can be classified into each of these three dimensions.

Depending on the size of the primary muscle engaged, skills are classified into gross motor skills and fine motor skills (Figure 1.1). Gross motor skills are those that require the use of relatively large musculature to produce an action. These skills usually need less movement precision than fine motor skills. Fundamental motor skills such as walking, running, jumping, throwing, balancing, and climbing are gross motor skills. Gross motor skills typically involve many muscle groups and, frequently, movement of the whole body. On the other hand, fine motor skills are typically performed by recruiting small muscle groups such as those of the fingers, hands, and forearms, and require little muscle strength or energy to perform successfully. Examples of fine motor skills include handwriting, sewing, buttoning a shirt, the use of precision tools, and the triggering action in shooting. In all these cases, it is the precision of the movement itself, and not the strength with which it is done, that allows to successfully execute the skill.

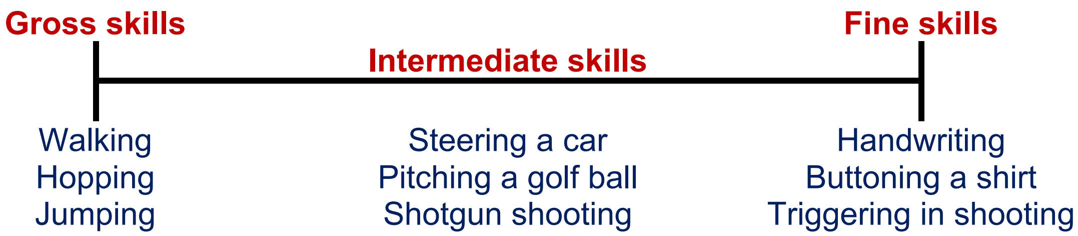

Figure 1.1. Classification of motor skills along the gross/fine continuum.

A second way of classifying motor skills is based on their temporal characteristics with respect to their beginning and ending. Accordingly, motor skills are classified as discrete, continuous, or serial (Figure 1.2). Some skills have specific start and end points and are classified as discrete motor skills. They are usually completed quickly, in a relatively short period of time (i.e., a fraction of a second to a few seconds). Examples of discrete motor skills include serving a tennis ball, throwing darts, standing up from a sitting position, hitting a baseball, and shooting in shooting sports. At the other end of the continuum we find continuous motor skills, those in which both the beginning and the end are arbitrary and unpredictable. These are often, but not always, repetitive and rhythmic in nature. Examples are walking, swimming, cycling, running, and rowing. The individual decides when to end a continuous skill and often when to start it. Between the two extremes lie serial motor skills consisting of a sequence of discrete elements, such as typing, performing a gymnastics routine, playing the piano, and dribbling a basketball.

Figure 1.2. Classification of motor skills along the discrete/continuous continuum.

A third way to classify motor skills is based on the stability and predictability of the environment in which they are performed (Figure 1.3). Closed motor skills are those in which the environment remains relatively constant and predictable from the time the skill is performed until the next execution. The performer usually decides (or has some time to decide) when to start the action, as well as when to stop and start again. For this reason, closed motor skills are also referred to as self-paced motor skills. Examples of closed skills are target shooting, dart throwing, bowling, swimming, and volleyball service. Unlike closed skills, open motor skills are performed in a changing, unstable, and unpredictable environment. The performer cannot effectively plan the whole action in advance. Examples are the many skills involved in all situational sport disciplines, such as fencing, wrestling, tennis, basketball, volleyball, and rugby, in which the performer must adapt to the actions of others (i.e., opponents and/or teammates). The correct execution of the skill, or even the decision as to whether or not a skill should be performed, cannot be precisely planned in advance. Between closed and open motor skills there are actions carried out in a relatively unstable environment, which to some extent are predictable and of which the performer has a certain level of control, as happens in windsurfing, kayaking, and skiing.

Figure 1.3. Classification of motor skills along the closed/open continuum.

STAGES OF LEARNING

The learning process that individuals go through when acquiring motor skills of different type and complexity is similar. There are identifiable behavioural stages that all people experience in the acquisition of motor skills. These phases can be experienced at different speeds, sometimes markedly different from one individual to another for a same skill, but the transition through each phase occurs in all people who learn a new skill. Effective coaches are able to identify in which phase of learning (i.e., initial, intermediate, and advanced) their athletes are and, consequently, are able to tailor instructional and practical experiences to best meet the needs of the learners at that moment. Indeed, the ability to distinguish between the stages through which people progress in the acquisition of motor skills is a requirement for implementing effective instructional strategies and is one of the hallmarks of good coaches.

Fitts and Posner Stages of Learning

In 1967, Paul Fitts and Michael Posner proposed three stages (or phases) of learning: cognitive, associative, and autonomous (see Figure 1.4, upper part). Since then, the model has become the most widely accepted and used in the field of learning and teaching of motor skills. Learners gain a better understanding of the skill and improve their ability to execute the skill as they move from one stage to the more advanced stage (see Table 1.3). It should be noted, however, that skill learning is best viewed as a progressive, continuous, and dynamic process that does not necessarily take place in clearly distinguishable and defined phases.

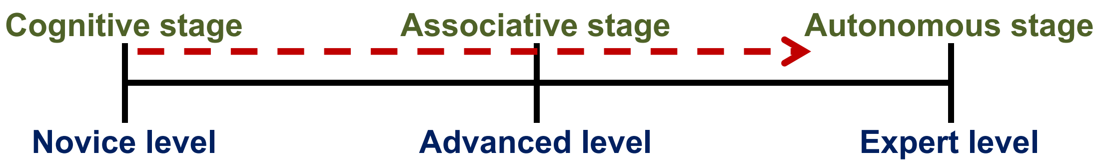

Figure 1.4. Fitts and Posner model (upper part) and dynamic systems model of the stages of learning (lower part).

Different cognitive, perceptual, and motor processes are involved in the different points of the learning process. In the ***cognitive stage*** the learner tries to grasp the basic idea of the skill and understand what exactly needs to be done. Even when learners initially understand the idea of the movement and its purpose, they may not understand the correct movement patterns needed for execution. At this stage, cognitive mental processes dominate, and movements are controlled in a relatively conscious manner. This stage has also been labelled “verbal stage” because learners often use overt or covert self-talk (inner dialogue, sub-verbalization) in an attempt to guide their actions. They tend to pay attention to the step-by-step execution of the skill and, as a consequence, the resulting movement is relatively slow, abrupt, and inefficient, and performance is rather inconsistent. The errors are frequent, large, and very different in type and extent. Learners may perceive that their movements do not meet the goals of the skill they are learning, but they do not know how to correct them.

This can lead to feelings of confusion, frustration, and decreased motivation. In this phase learners do not have the necessary knowledge to understand and use the information that comes from the environment and their movement, produce correct movement patterns, and evaluate the results of their action. They need to understand the correct mechanics of the action and how to interpret and use information from both the environment and their body to produce the correct action. Therefore, performers depend heavily on the instructions and feedback provided by an external source (e.g., the coach).

The length of this cognitive phase of motor learning depends on a number of factors. Learners can pass this phase after making a few attempts or trying the skill for a few minutes, especially if they have already experienced similar tasks or if the skill to be learned is simple. For complex skills the duration of the first phase can be much longer, especially for inexperienced people. With effective practice, however, almost everyone is able to pass this learning phase for most motor skills and thus reach the next phase.

The ***associative stage*** of learning begins when the learner has acquired the basic movement pattern and the main objectives of a skill. As a result, we can observe a number of behavioural changes. In this phase, more subtle movement adjustments occur, errors become less frequent, the type and magnitude of errors decrease, the action is more consistent from trial to trial, the outcome is more reliable, ineffective co-contractions are gradually reduced, and the movement becomes smoother and more efficient (i.e., executed with less energy expenditure compared to the cognitive stage). Much of the irregularities that typify the earlier learning phase disappear as various components of a skill become more effectively integrated and connected each other. Furthermore, the need to consciously control every aspect of the action is progressively lessened. Therefore, at least parts of the movement are performed under a more automatic control, and more attention can be directed to other aspects of the performance. Performers begin to integrate aspects of the environment into their performance by linking sensory input with appropriate movement responses. This allows the performer to adapt better to environmental changes. The need for "self-talk" or sub-verbalization decreases during this stage. Performers can now make changes to movement patterns based on situational changes, for example by speeding up or slowing down movements in relation to changes in environmental conditions.

The amount of time a learner will remain in the associative stage (and also in the cognitive stage) depends on several factors, such as the complexity of the skills, the individual abilities and skills already acquired, and the quality of teaching. Highly complex skills can take many weeks or months of practice before the performer is able to move on to the next stage. Although many learners can reach the associative stage rather quickly, they may not be able to advance to the next stage. For complex skills, reaching the autonomous stage of learning may require specific individual skills, adequate motivation, and effective teaching strategies.

After extensive practice, the performer reaches the ***autonomous stage***. This phase is characterized by fluent and seemingly effortless movements. The actions are very accurate, consistent, efficient, with little or no errors and relatively little muscular energy required. Individuals are able to adapt their movements to a wide range of environmental situations. The skill is carried out largely automatically, and movement execution requires little or no attention to the mechanics of the skill. Performers no longer have to think about how to perform the skill and can even forget how exactly they perform, even though they are able to execute the skill with high proficiency. Attention can be directed to other areas of interest. Indeed, an indication that individuals have reached the autonomous stage is their ability to maintain good performance standards while thinking about something else, to direct attention to cues unrelated to performance or, conversely, to mentally anticipate events related to performance in order to adapt the action effectively to environmental changes. Performers are able to detect their mistakes, analyse the causes of ineffective performance, and find ways to correct mistakes and attain their goals. Movements are executed effectively (the goal of the skill is reached) and efficiently (with an optimal amount of energy invested). Reaching the autonomous stage typically requires considerable practice, even greater than that necessary to attain the associative stage, high motivation, motor capabilities, and effective teaching strategies.

As illustrated in Figure 1.4, progression through stages is best regarded as continuous rather than discontinuous, with progression advancing through practice from cognitive to autonomous stages. Progress from stage to stage is most often gradual rather than marked by sudden shifts in performance. For this reason, it is often difficult to detect at what stage an individual is at a particular time.

Table 1.3. Fitts and Posner stages of learning and their characteristics.

Cognitive stage (beginner)
• Many errors • Great variability in errors • Irregular movement patterns • Blocked joints, rigidity, and movement limited • Stiff muscles in complex movements • Slow response time • Conscious attention directed to control most skill elements • Sub-verbalization (“self-talk”) • Stereotyped movements not adaptable to environmental changes • Slow, inconsistent, and ineffective movements • Considerable cognitive activity • Poor performance
Associative stage (intermediate)
• Decreased frequency of errors • Less pronounced errors • Understanding of basic skill requirements • Faster, smoother, and more effective movements • Joints released; wider and more flexible movements as synergies develop • Automatic execution of some movement segments and conscious control of other parts • Greater movement adaptability to environmental changes • Less cognitive activity required • Higher performance
Autonomous stage (advanced)
• Few errors • Small variability in errors • Smooth, fluid, coordinated action • Quick response in skill execution and fast decision making • Integration and connection of all skill components • Movement execution in interaction with the external environment • Ability to attend to performance-related or unrelated cues while executing • Great movement adaptability to environmental changes and different contexts • Ability to detect errors and find solutions • Minimum (optimal) energy expenditure • Accurate, consistent, and effective actions • Low or no cognitive activity required • Movement largely controlled automatically • High performance

Dynamic Systems Model Stages of Learning

Another perspective of the learning process is offered by the dynamic systems theory. This theory recognizes the same behavioural characteristics of the Fitts and Posner model that learners manifest as they acquire motor skills, however the interpretation is different. A fundamental principle of the theory is that movement patterns emerge from the interaction between the ***organism*** (the performer), the ***task*** to be performed, and the ***environment*** in which the action takes place (Figure 1.5). The constraints derived from the interaction of these three components provide the boundaries of the possibilities of movement and shape movement in preferred patterns. Constraints do not impose particular movement patterns, but make certain patterns more likely to emerge, those that produce the highest degree of stability. Coordination emerges as learners adapt their movement behaviours to the constraints imposed on them and learn to exploit their movement environment in order to take greater advantage of these constraints. The fundamental challenge faced by learners is how to control the vast number of movement possibilities they have. According to this view, coordination (i.e., learning skills) is the learning process to control the many possibilities (i.e., degrees of freedom) available within the human movement system.

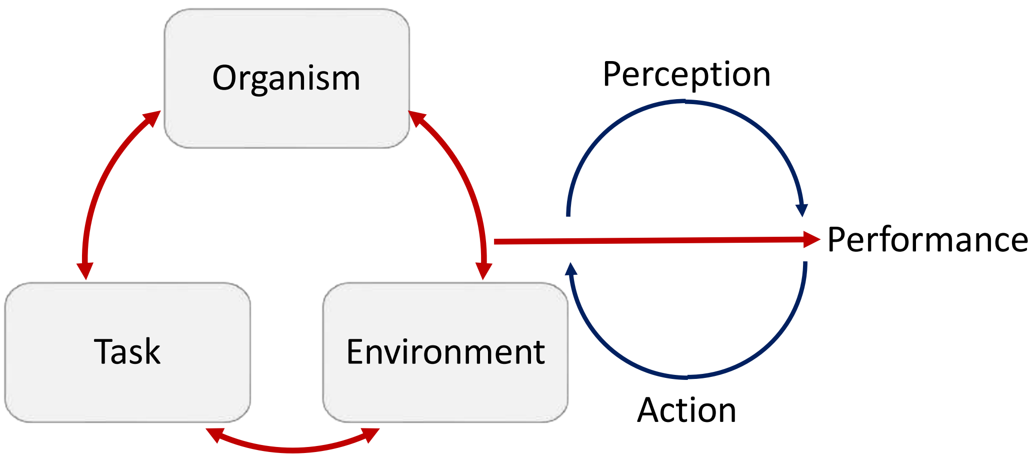

Figure 1.5. Interaction between organism (performer), task, and environment constraints underlying coordination patterns in goal-directed behaviour.

The three learning stages are called novice, advanced, and expert (see Figure 1.4, lower part). In the ***novice stage*** of learning, the main challenge for the learner is how to control and coordinate the many muscles and joints involved in the movement. This requires control of many independent possibilities of movement (i.e., degrees of freedom) of the muscles that control the joints underlying the action. The learner simplifies this difficult task by reducing the number of individual elements that need to be controlled. This is achieved by freezing the degrees of freedom in the movement systems involved in the production of the skill. This entails blocking some joints of the limbs so that they move in a unitary way, rather than as a system where each joint is free to move independently. For example, a child can only use the arm to throw a ball. The legs and most part of the trunk do not intervene to assist the throw as they do in more advanced throwers. Inexperienced throwers also eliminate the backswing, and the throw is completed almost exclusively by using the elbow joint and part of the trunk as a single action unit. By freezing some degrees of freedom while keeping various limbs and regions of the body rigid and fixed, the number of degrees of freedom that must be controlled by the novice is reduced to a manageable number. This behaviour, however, is insufficient to allow coordinated and effective control of movements. Performance improvement is only possible when some of the degrees of freedom (i.e., the possibilities of movement) are released to be independent (or relatively independent) of the actions of other parts of the body. Learning takes place through trial and error experiences. Gradually, learners begin to release some degrees of freedom, allowing some joints and segments of the body to move more freely, and explore movement possibilities and outcomes. At this point, joints can be controlled more flexibly, independently, and effectively.

In the ***advanced stage*** of learning, after exploring the possibilities of action, the performers learn to free more and more degrees of freedom of their movement in order to achieve optimal coordination patterns. At this stage, previously frozen joints can be incorporated into larger and more sophisticated units of action. These are called coordinated structures or synergies. Synergies are groups of muscles that often span multiple joints linked together and act as a single unit when activated. Through the learning stages, performers acquire the ability to control many more independent movements of muscles and joints. They become able to coordinate complex actions that often involve whole-body movement patterns. The action is fluid, well-coordinated, and relatively effective.

After achieving movement coordination, in the ***expert stage*** of learning the performers are able to exploit the passive and reactive forces in the body system (i.e., muscles and joints) and in the environment. In this phase, the performer continues to release degrees of freedom and to rearrange the others in order to obtain the most efficient movement patterns in terms of energy expenditure. The main focus at this stage, however, is on the exploitation of internal and external forces, which can significantly contribute to the effectiveness of the movement. In the example of throwing a ball, the child froze most of the body's movements and rigidly move the arm and torso as a single unit of action. In the advanced stage, the child can take advantage of some combinations of arm extension and torsion of the trunk and recognize that some movements are more effective than others to produce strength. Through the continuous exploration of the possibilities of movement, the child will learn to spread the legs, twist the upper body, and extend the arm well before throwing the ball, thus taking advantage of the elastic properties of the musculature and the biomechanical forces inherent in the action. Learners also acquire the ability to exploit the physical properties of the environment such as the inertia, friction, and gravity intrinsic to the environmental context, thus achieving better coordination, greater performance competence, and wider flexibility of movement.

INSTRUCTIONAL PRIORITIES IN THE STAGES OF LEARNING

As performers progress through the stages of learning, they need different instructional strategies. Teaching strategies that can be helpful in one stage can actually be less effective in another stage or even hinder learning. As previously discussed, beginners have to voluntarily control the action and develop a cognitive understanding of a skill, while at a later stage they can start to control the action more automatically.

A number of fundamental instructional strategies will be presented in detail in the next chapters, while others, regarding goal setting, instructions, demonstrations, and feedback, have been discussed in the sports science booklet of the ISSF National Coach (first level) Course. Table 1.4 contains a summary of important instructional strategies coaches should use with their athletes across the stages of learning based on Fitts and Posner and the dynamic systems model classifications.

Table 1.4. Instructional strategies in the stages of learning based on Fitts and Posner and the dynamic systems model classification.

FITTS AND POSNER	**DYNAMIC SYSTEMS**
Cognitive stage (beginner)	**Novice stage**
• Use verbal instructions and demonstrations to help learners mentally form a basic idea of the skill and the goals of the action • Involve learners in the goal setting process • Provide short information and keep it concise • Help learners identify and differentiate appropriate sources of information on the environment • Highlight to learners how their acquired skills and knowledge can be transferred to the new situation • Provide relatively frequent feedback regarding main errors • Reinforce individual's performance improvements, participation, and efforts in order to enhance motivation and interest • If necessary, simplify techniques, for example when the skill is very complex, or the individual level is very low	• Present the learner with the goal of the skill to perform • Facilitate and encourage the learner's attempts to explore action possibilities and to discover movement solutions • Ask questions to direct the learner's attention to relevant cues and perceptual information and provide adequate feedback • Change task demands (e.g., balance, timing) according to the learner's ability to adapt • Change environmental constraints (e.g., distance, target, rules) according to the learner's ability to adapt

Table 1.4. continues

Table 1.4. continued

Associative stage (intermediate)	Advanced stage
• Encourage learners to identify and respond to changes in environmental conditions rather than focusing primarily on movement mechanics • Increase movement variability • Gradually withdraw the amount and type of feedback provided to learners • Encourage learners to evaluate and correct their errors on their own • Reinforce correct movement behaviours • Instruct learners to redirect attentional resources (especially visual ones) to appropriate cues in the environment • Continue to reinforce improvements, participation, commitment, and effort	• Continue to encourage learners to explore movement possibilities while changing movement requirements and environmental demands • Change practice environments • Change task demands systematically (e.g., balance, timing, movement symmetrisation) • Change environmental constraints systematically (e.g., light, distance, target, rules, weather conditions)
Autonomous stage (advanced)	**Expert stage**
• Try to keep learners' motivation levels high, despite the difficulties that can be encountered in reaching even small improvements in performance • Emphasise that improvements can be achieved through continuous involvement and dedication • Focus instructions on how to refine movements and adapt them to varying situations • Help learners to refine and adapt their well-learned skills to meet the demands of a wide range of environmental conditions • Encourage learners to analyse in detail their performance and find personal solutions to the difficulties encountered in both practice and competition contexts	• Design variable training sessions that encourage performers to further improve and extend their problem solving and adaptation skills to the situational demands • Continue to change practice environments • Simulate competition • Continue to change task demands systematically (e.g., balance, timing, movement symmetrisation) • Change individual constraints (e.g., fatigue, physical activation, stress, emotions) • Continue to change environmental constraints systematically (e.g., light, distance, target, rules, weather conditions) Fully engage performers in the learning process across all stages of learning

The applied indications deriving from the two different models can be harmonized in effective instructional activities. The Fitts and Posner model is more focused on individual changes during the learning phases, while the dynamic systems model considers the interaction between individual, task, and environment in explaining motor behaviour and the acquisition of skills, and in identifying instructional strategies. Both models contribute to our understanding of how people learn motor skills and offer practical indications that can be used to structure, design, and implement instructional activities according to the individual's needs and learning stages.

SUMMARY

Motor skills, including many different technics in sport, involve three important aspects: (1) the cognitive component – deciding *what to do* to attain the performance goal; (2) the perceptual component – deciding *where and when to do it* in function of environmental cues; and (3) the movement component – deciding *how to do it* (i.e., how to organise muscles activity to generate effective actions).

Motor skills can be classified along the two ends of a continuum as: (1) gross–fine, based on the size of the primary muscle groups involved, (2) discrete–continuous, depending on the temporal features of the skill relative to its beginning and ending, and (3) closed–open, in function of the stability of the environment in which the skill is performed. All motor skills can be classified into each of these three dimensions.

In learning motor skills, the performers go through different stages typified by specific cognitive processes, behaviours, and interactions with the environment. According to both Fitts and Posner and dynamic systems models, in the initial phase of learning (the *cognitive* or *novice stage*), novices struggle to grasp the basics of action in an attempt to form a mental picture of the goals of movement and correct mechanics of a skill. Most elements of a skill are controlled in a relatively intentional (conscious) way. The errors are frequent and large in magnitude, and performance is poor. The learner tends to block ("freeze") some joints while coupling others, maintain the rigidity of the body, and limit the movement of joints, limbs and body components.

In the intermediate phase (the *associative* or *advanced stage*), the need to control every aspect of the action is gradually reduced. Therefore, more parts of the skill are executed under automatic control and, consequently, more attention can be directed towards other aspects of the performance. Movements become more consistent, precise, economical in terms of energy expenditure, and effective in terms of the goals that can be achieved. The performer can release ("free") frozen joints and limbs as synergies develop. The control of action and movement flexibility are improved.

In the final phase (the *autonomous* or *expert stage*), performers automatically execute most or all components of a skill without depleting attentional resources. Movement coordination is high, and performers are able to effectively adapt the patterns of their action to deal with environmental changes. Performers use ("exploit") the passive and reactive forces of the body system and the external environment that contribute to the dynamics of the movement.

Coaches should be aware of the need to apply different teaching strategies as people progress through the learning stages. Numerous teaching strategies are identified in the different stages of learning based on the Fitts and Posner and Dynamic Systems models.

Suggested Readings

Edwards, W. H. (2011). Motor learning and control: From theory to practice. Belmont, CA: Wadsworth, Cengage Learning. Chapters 2 & 7.

Ives, J. C. (2014). Motor behavior: Connecting mind and body for optimal performance. Philadelphia, PA: Lippincott Williams and Wilkins. Chapters 6 & 7.

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Schmidt, R. A., & Lee, T. D. (2020). Motor learning and performance: From principles to application (6th ed.). Champaign, IL: Human Kinetics. Chapters 1, 8, & 9.

Self-Evaluating Questions

- How are motor skills defined and what are their main elements?
- What is the difference between motor abilities and motor skills?
- What factors influence the performance of motor skills?
- How can motor skills be meaningfully classified?
- Provide examples for each of the three classifications of motor skills.
- Compare and contrast the learning stages according to the Fitts and Posner and Dynamic System models.
- Discuss the instructional priorities for each stage of learning based on the Fitts and Posner and Dynamic System classifications.
- Choose a technical shooting skill and discuss the behavioural aspects of performance for a shooter in each of the three learning stages and develop strategies to instruct the shooter in each stage.
- Discuss how you can change task demands, individual constraints, and environmental constraints to improve and refine the performance of an expert shooter.

Practical Activities in the Field for Learning Motor Skills

- Use instructional strategies based on the Fitts and Posner classification to help your novice shooter learn a technical skill.
- Drawing on the dynamic systems classification, use instructional strategies to help your novice shooter learn a technical skill.
- Invite your expert athlete to analyse in detail their performance and find personal solutions to the difficulties encountered in both practice and competition contexts.
- Change task demands to improve and refine performance of an expert shooter.

- Change individual constraints to improve and refine performance of an expert shooter.
- Change environmental constraints to improve and refine performance of an expert shooter.
- Design training methods based on the Fitts and Posner and dynamic systems classifications and ask your expert shooter to try both:

FITTS AND POSNER **Autonomous stage (advanced)**	**DYNAMIC SYSTEMS** **Expert stage**

Power Point Presentation

Slides 1 to 25.

CHAPTER 2 – SCHEDULING PRACTICE

OVERVIEW

Practice is essential for learning. It is the main factor that determines the transition from an initial stage of learning to more advanced phases of proficiency and expertise in sport. Simply put, *practice is learning*. People have innate abilities that can make learning a particular skill relatively easy. Nevertheless, a great deal of practice is still required to improve and optimize the performance of complex actions.

Although individual physical and cognitive maturation influences skilled performance behaviour, motor learning is specifically defined with respect to changes that occur as a result of experience or dedication to practice. Performance improvement through learning consists of a change in the quality of movement production (increase in efficiency) and/or a greater probability of success in achieving the results of the action (increase in effectiveness, such as improvement in response consistency or error reduction).

Practice is so critical for learning to occur that sometimes coaches tend to focus on repetition and neglect the quality of practice experiences. However, simply repeating skills over and over does not guarantee good levels of success. In fact, the quality of practice is as important as the time spent practicing. Researchers and practitioners have highlighted a wide range of instructional methods that coaches should adopt when designing practice experiences of quality. The methods coaches choose and how those methods are arranged during training play a major role in the acquisition and retention of skills.

The effectiveness on learning of one particular form of practice compared to another depends on variables such as age, experience, and type of skill. However, the same amount of practice can either result in little learning or, conversely, in substantial improvement in skill level, depending on how practice experiences are designed. Table 2.1 contains some of the most important instructional schedules presented in this chapter.

Table 2.1. Instructional schedules for learning.

Distribution of practice: massed vs distributed	
Distribution of practice	How the frequency and amount of rest are scheduled between practice sessions and within the session.
Massed practice	A practice schedule in which the amount of rest between practice sessions or trials is relatively short.
Distributed practice	A practice schedule in which the amount of rest between practice sessions or trials is relatively long.
Practice variability: constant vs variable	
Practice variability	The variety of movement and context characteristics that a person experiences while practicing a skill.
Constant practice	A same skill is repeated in the same way, without variations, in a fixed context in a series of trials.
Varied practice	A same skill is repeated in a variety of different ways and contexts.
Contextual interference: blocked vs random or serial practice	
Contextual interference	The memory and performance difficulties (i.e., interference) that result from performing multiple skills, variations of a skill, or both within the context of practice.
Blocked practice	A single motor skill is practiced completely before moving to the next motor skill and so forth.
Random or serial practice	A number of skills are practiced in an unpredictable order (i.e., random) or in a pre-ordered sequence (i.e., serial) for several times.
Contextual interference effect	The learning benefit resulting from performing multiple skills in a high contextual interference practice schedule (i.e., random or serial practice), instead of performing the skills in a low contextual interference schedule (i.e., blocked practice).
Part vs whole practice	
Part practice	Simplified performance of a skill, involving either the initial practice of component parts of the skill or the simplification of environmental features in which the skill is performed.
Whole practice	Practice of a skill in its entirety as it is intended to be performed as a result of practice.

INTRODUCTION

There is consensus among theorists and practitioners that practice is the single most important factor in the learning of motor skills. According to the *law of practice*, performance improvement continues providing that practice continues, even though the rate at which improvement occurs gradually decreases over time or number of trials.

When learning of a new motor skill, rapid performance improvements usually occur during the initial training periods. As practice continues, the rate of performance improvement slows down while the time needed to observe small changes begins to take longer and longer. This negatively accelerated performance curve is represented in Figure 2.1 considering the stages of learning discussed in the previous chapter. This typical pattern of behavioural change depicts learning rate of virtually all motor skills. The upper limit of learning is progressively reached with training. Although potential improvements are always possible, performance tends to stabilise over time.

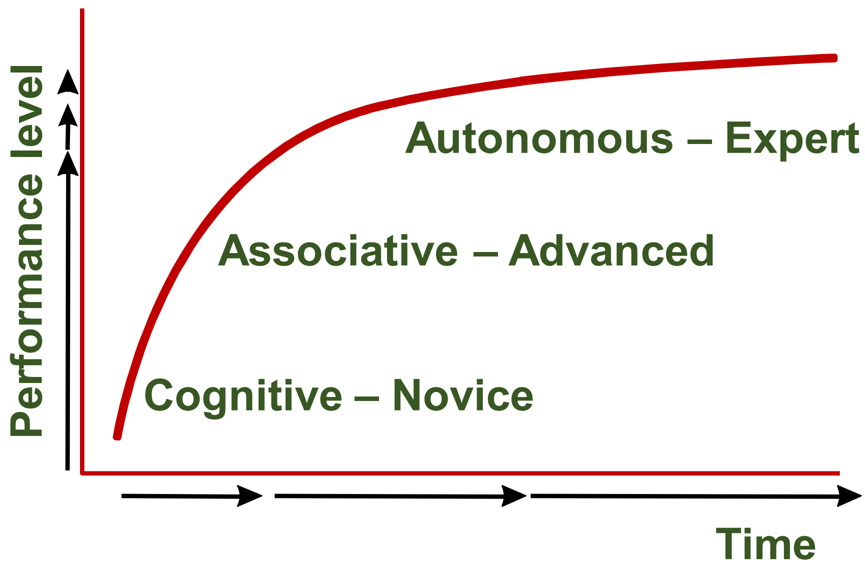

Figure 2.1. Learning stages over practice time.

The amount of practice is of paramount importance, but alone is not enough and must be combined with quality of practice. Practice quality, in fact, is essential to improve and optimize learning, as it plays a fundamental role with respect to the speed, stability, and level of acquisition that will result.

When planning training sessions, coaches must make a number of decisions about scheduling activities. These include the way in which sessions are distributed over time, whether skills should be practiced in a constant manner or in a variety of ways, the order in which skills should be practiced, and whether to learn complex skills in parts or as whole actions.

Importantly, coaches should be aware that many ways of scheduling training sessions, which stem from common beliefs and often seem intuitively out of question, are not the most effective ways to teach motor skills. Although learning manifests itself in changes in behavioural outcomes, the internal processes and states that influence an individual's current performance are not necessarily related to learning. For example, fatigue after a long training session can result in significantly reduced performance, or the presence of a particular incentive could push an individual to a high but atypical level of performance. Therefore, immediate conclusions about the effectiveness of a practical intervention could be masked by these temporary performance factors. Instead of focusing on short-term (immediate) improvements, which are often very instable, coaches would do better to devise intervention strategies to help their performers: (a) achieve long-term lasting results, and (b) transfer skills acquired from practice to competition.

MASSED AND DISTRIBUTED PRACTICE

A decision that coaches must make concerns the ***distribution of practice***, namely, balancing the periods of work and rest ***between*** and ***within*** the practice schedules (see Figure 2.2). The questions are:

- Is it better to condense the practice sessions more closely over time (***massed practice***), or is it preferable to space the sessions over longer periods of time (***distributed practice***)? This problem concerns *practice distribution between sessions*.
- Should a single practice session contain short rest periods between trials (***massed practice***), or should the session include longer break periods (***distributed practice***)? This question regards *practice distribution within a session*.

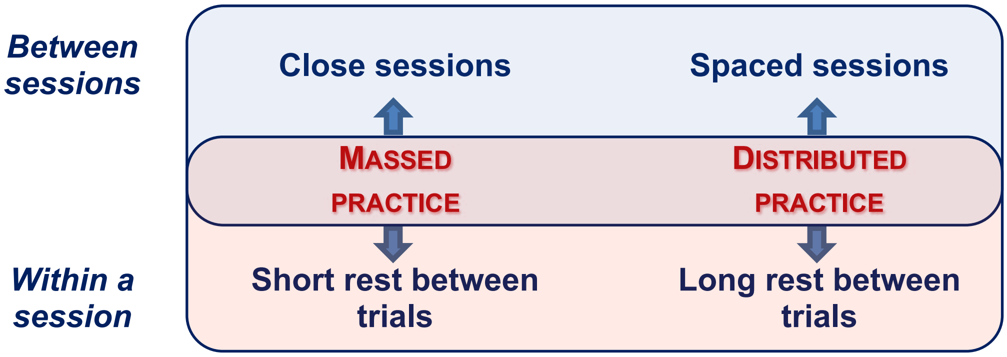

Figure 2.2. Distribution of practice for learning.

Practice Distribution Between Sessions

There is a general consensus among researchers and practitioners that distributed practice benefits learning more than massed practice. In general, for the same overall practice time and total number of repetitions of a skill, shorter practice sessions, distributed over longer periods of time, are more effective for learning than sessions where the practice is concentrated in longer sessions and shorter periods of time.

But why is distributed practice between sessions better than massed practice? There are several explanations.

- One possible reason is related to the memory encoding and consolidation. Memory traces in the brain are made permanent through a series of biochemical processes that take time to complete. The distribution of practice allows more time for these encoding and consolidation processes to take place.
- A second explanation concerns the brain processes that occur during sleep. Sleep has been shown to be essential for the consolidation of memory traces, including motor skills. The distribution of practice over time translates into a greater number of training experiences followed by periods of sleep. This would lead to greater reinforcement of memory traces in the brain.
- Another reason relies on the cognitive effort and motivation effects associated with distributed practice. Spacing practice, in fact, can increase the amount of cognitive

effort in the learners whose cognitive acquisition processes are continuously stimulated over time. On the contrary, the repetitive practice experiences that characterize massed practice can become monotonous and boring. This would lead to lower learning outcomes as learners decrease the amount of cognitive effort they exert to perform the motor task.

Taking these reasons into account, it can be concluded that the distribution of learning experiences over long periods (months or years) promotes better learning than concentrating practice sessions over short periods of time.

Practice Distribution Within a Session

As for the practice of skills within a single session, it is important to distinguish the effects of the practice on continuous or discrete motor skills. In continuous motor skills, the beginning and end of the action are unpredictable and not obvious (see Chapter 1, classification of motor skills). Examples are repetitive and rhythmic actions, such as walking, running, cycling, and swimming, but also tracking skills, such as steering a car. On the other hand, in discrete motor skills, the starting and ending points of an action are clearly defined, observable, and predictable. Actions of this type are typically performed in a relatively short period of time. Examples include serving a volleyball, hitting a penalty kick in soccer, and throwing darts.

Shooting sports involve executing discrete skills in which the technical components are organized and integrated in a sequential order into a continuous movement pattern. In this sense, shooting can be considered a serial skill, in which discrete actions are tied together to make a new and complex movement (see Chapter 1, Figure 1.2).

Research evidence on continuous skills supports the conclusion that distributed practice promotes better performance and learning than massed practice. This may appear to be a rather obvious conclusion. Distributed practice, indeed, leads to less physiological and psychological fatigue because of the inclusion of multiple pauses between tasks. Conversely, imposing higher demands on learners through massed practice tends to increase the level of fatigue and decrease the ability to act skilfully during training.

Research findings do not lead to such clear conclusions for the learning of discrete (and serial) motor skills. However, available evidence suggests that massed practice is more effective than distributed practice for the learning of discrete motor skills. Most experts believe that mass practice, although it may depress immediate performance, promotes long-term learning and retention. Within session, therefore, massed practice schedules for discrete skills are preferable over distributed schedules.

The suggestion to use massed practice schedules agrees with the need to provide learners with sufficient practice experiences. Given the limited time normally available in actual training contexts, removing unnecessary rest breaks between discrete (or serial) tasks allows for more time devoted to the activity. Indeed, as previously pointed out, the amount of practice time and number of task repetitions are essential ingredients for learning.

An alternative and effective way of using distributed practice is to insert demonstrations, observation of others' execution, instructions, reflective thinking, self-evaluation of performance (see the booklet for the ISSF National Coach – first level – Course), and imagery (see Chapter 3 in this booklet) during breaks between practice trials. Instead of seeing rest as lost time, performers can use their breaks productively to improve motor learning while recovering from fatigue.

CONSTANT AND VARIABLE PRACTICE

Practice variability can be conceptualised as the practice that includes variations of the skill itself or the context in which the skill is performed. In the continuum ranging from constant to variable, ***constant practice*** occurs when the skill is performed each time in the same ways and conditions, while ***variable practice*** refers to variations in the execution of the skill or in the conditions in which the task is performed (Figure 2.3).

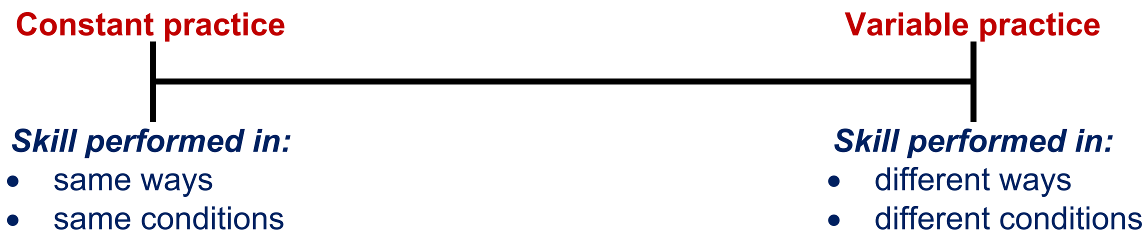

Figure 2.3. The constant/variable practice continuum.

Variable practice has been shown to be superior to constant practice for learning a wide range of motor skills, especially (but not only) in youngsters. Variable practice tends to improve the individual's ability to perform the skill in a variety of ways and in different environmental contexts and circumstances (e.g., practice and competition). The benefits of variable practice may not appear in immediate performance but rather emerge in the long term. Variability can actually adversely affect immediate performance during learning, but will ultimately improve learning. Furthermore, there is agreement that variable practice is more productive after the learner has passed beyond the first stage of learning and has grasped the basics of the skill. This would prevent to overwhelm the learner with too much variability too early.

Variable practice is very important in open skills (see Chapter 1, classification of motor skills) because these inherently include variability. But even in closed skills there are benefits from variable practice. Variations in execution can involve a change in movement parameters, such as speed, force, direction, trajectory, and distance. In pistol and rifle, for example, the task can be completed with different speeds by alternating between slow, fast, and normal shooting speed or pacing between shots. It should be emphasized that the shooter's ability to adapt the shooting action to environmental constraints, such as light, wind, and sudden changes in weather conditions, is a requirement for good results.

In clay target shooting, the variations are naturally found in the vast assortment of trajectories, angles, speeds, elevations, and distances that targets are thrown at. Therefore, the goal of training is to acquire the ability to perform shooting in a variety of different circumstances. More generally, the goal of the practice is to improve the ability to perform skills in new ways, in different environments, and in different conditions.

Different theoretical perspectives converge on the idea that practice variability is beneficial for long-term learning. Practice variability leads to a better development of the memory traces underlying the skill, because the memory of the skill can be generalized in the different ways in which the action can be performed. According to the variability of practice principle, therefore, variations in the task are fundamental for the development of the memory of a skill. This translates into better learning than constant experiences. According to dynamic systems theory, variability offers learners the opportunity to explore and discover the perceptual motor range of possibilities so that they can assemble functional motor patterns.

Beyond memory effects, and similarly to the previously discussed distribution of practice schedule, the benefits of practice variability on learning can be due to cognitive effort and motivation. Variability, indeed, requires more cognitive effort and attention from learners, and these conditions can enhance motivation and commitment to the task. Constant repetitive practice, on the other hand, can easily lead to boredom and decreased motivation.

Linked to the concept of practice variability is the ***principle of practice specificity***. According to this principle, the transfer between what is learned during practice and what has to be done later in real-world contexts depends on the similarity between the elements of the practice and subsequent performance conditions. In other words, the greater the degree of similarity between the various elements of training with those of the performance setting (e.g., competition), the greater the degree of transfer between the two areas and the better the learning outcomes. Therefore, effective training experiences should reflect the variability in the execution of the skills and environmental conditions in which future performance will take place.

It should be noted, however, that there are occasions when relatively good performance during acquisition is more easily achieved through constant practice rather than varied practice. For example, constant practice can be more useful when the skill is very complex for the individual or during the early stage of learning, when novices may experience skill variations as too confusing. Sometimes it is also possible to schedule constant practice during the most advanced stages of learning when the goal is to stabilize behaviour. Hence, the decision to employ varied practice requires careful consideration of the learning stages, skill complexity, and learner's ability.

BLOCKED AND RANDOM/SERIAL PRACTICE

In the previous section, we examined variable practice of a single skill. Variability can also be viewed as the scheduling of repetitions among several skills. This type of variability is also known as inter-skill or between-skill practice and, once again, it can be represented along a continuum ranging from blocked practice to random/serial practice (Figure 2.4).

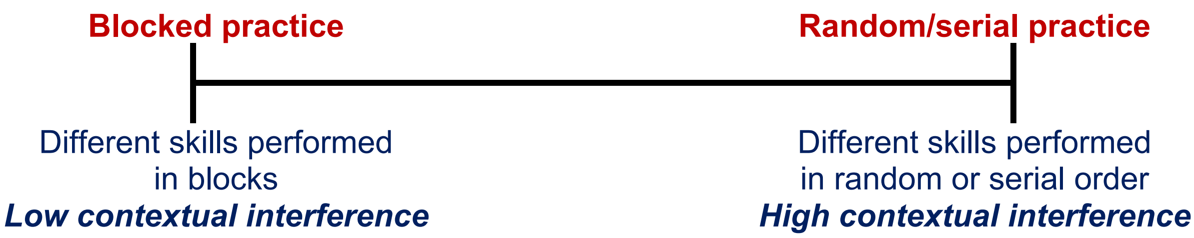

Figure 2.4. The blocked/random(serial) practice continuum.

It should be noted that practicing a variety of different skills during a session is the most common type of training. But how can different skills be arranged in one session? To answer this question, we need to understand the difference between blocked and random/serial organisation of practice.

Blocked Practice

Blocked practice is when different skills are performed in blocks without interference of other skills, thus leading to low contextual interference. On the other hand, random or serial practice is when a number of skills are executed in random or serial order, thus resulting in high contextual interference. In a blocked schedule, for example, a tennis player may continuously practice 15 forehand strokes, 15 backhand strokes, and 15 serves, for a total of 45 trials. In a random practice, the player may perform two or more attempts of each skill in a random order for a total of 45 trials. In a serial practice arrangement (a version of random practice), the player may perform 5 forehand strokes, 5 backhand strokes, 5 serves, and repeat the whole sequence three times. It is important to note that the number of repetitions of each skill (i.e., 15) and the total number of strokes (i.e., 45) remain unchanged across the three practice organisation schedules.

Blocked practice typically leads to good immediate performance. This is because individuals can devote all their attention and memory resources to the skill and to the most appropriate environmental cues, while coaches can easily provide consistent instructions and feedback to help maintain high levels of performance. By repeating the same skill over and over, learners make adjustments from one trial to the next and refine their performance through repetition. Hence, skills in a blocked schedule have the best chance of being performed optimally. Performance improvement can momentarily enhance an individual's motivation because of high perceived success levels. However, these transient benefits tend to dissipate once practice is over.

Blocked practice, therefore, is not always the most effective arrangement of training experiences if the goal is to promote learning and retention over time. Immediate performance, indeed, is not always the best predictor of learning. There is strong research evidence across different tasks, people of all ages, and different levels of performance showing that blocked practice enhances short-term performance, but random practice leads to better learning, retention, and transfer. This outcome is termed the contextual interference effect.

Contextual Interference

Blocked practice is related to low contextual interference because the context in which skills are practiced remains constant from trial to trial, and the representation in memory of the skills remains fairly stable over practice attempts. Random practice, conversely, determines high contextual interference because the practice context changes constantly, leading to changes in memory states between practice attempts. As previously stated, there is robust research evidence showing that high contextual interference (i.e., random/serial practice) generally promotes better learning of motor skills compared to low contextual interference (i.e., blocked practice), although this advantage is often masked by poor immediate performance during acquisition. Indeed, despite creating problems with immediate performance during practice, contextual interference positively influences long-term learning. Good short-term performance (but poor long-term learning) achieved through blocked practice can mislead those athletes and coaches who struggle to reach 'perfect' performance during training. Thus, it is important that athletes and coaches acquire a more accurate sense of how learning progresses and the objectives of random/serial schedules.

Boyce and Del Ray (1990) found the contextual interference effect in a college riflery instructional setting, wherein participants were required to practice at different target locations. In a related study, Keller, Li, Weiss, and Relyea (2006) used pistol-shooting skills to examine the effects of blocked versus serial practice in adult beginners. Pistol shooting skills were learned in three stages. In a first stage participants were required to shoot four targets at graduated distances (i.e., from 6 to 15 yards) from the starting box using a sweeping motion from left to right or right to left as quickly as possible. In the second stage participants hit three targets arranged in close proximity while avoiding two other targets in the same area. In the last stage participants had to hit three targets arranged at three different angles from the shooting box.

A blocked group and a serial group were formed with half of the participants randomly assigned to each group. The blocked group performed 10 shots at each of the three stages, with all shots executed at one stage before proceeding to the next. The serial group executed the same number of shots at each stage using a serial format, with five trials performed at each stage before switching to the next. This procedure was repeated for a total of 30 shots. Findings showed that the serial schedule, despite having initially depressed performance, allowed to maintain better complex shooting skill performance over time compared to blocked practice. Although having a low cognitive complexity, the pistol shooting tasks involved high motor and perceptual process demands. In the condition of serial practice, when the participants were asked to move between the three stages, they were forced to switch the sensorimotor system from a readiness to perform at one stage to a readiness to perform at another stage.

Explaining the Contextual Interference Effect

There are several hypotheses put forward to explain the contextual interference effect. The two most important are the elaboration and the action plan reconstruction hypotheses.

The ***elaboration hypothesis*** assumes that when learners practice randomly and serially, they use more strategies to execute the skill rather than sticking to a plan as happens in the blocked situation. All the skills are kept in working memory at the same time, thus allowing the learner to elaborate the memory representations of the skills or skill variations. In particular, random practice offers more opportunities for learners to distinguish both similarities and differences among skills, including initial conditions, response parameters, and sensory consequences, thereby making the memory trace for each skill more distinct, meaningful, rich, and easy to recall. In a blocked practice condition, on the other hand, the attention focus is more on the specific features of a single task and on a rote execution of the task. This kind of focus of attention tends to exclude the cognitive processing necessary to enrich the mental representation of the task.

The ***action plan reconstruction hypothesis*** (or forgetting hypothesis) is grounded on the limited capacity of short-term memory. According to this hypothesis, learners involved in random and serial schedules experience partial or total forgetting of a skill during the periods in which they are working on other skills. Upon returning to the 'forgotten' skill, they have to reprogram the way in which they will perform it. In particular, when learners perform a skill, they process the relevant incoming sensory information and retrieve the action plan to guide the execution of the skill. When they shift to another skill, the action plan kept in short-term memory is replaced with the action plan for the other skill. The next time the previous skill is executed, the action plan for it must be reconstructed. This ongoing process of constructing, forgetting, and reconstructing the plan of action for a skill strengthens the memory trace of the skill. It is the cognitive effort associated with the recovery and construction of action plans that, in the long run, strengthens the consolidation process, thus promoting learning. In a blocked practice condition, in contrast, the action plan can be retrieved and kept in memory with little additional processing for each subsequent execution of the skill.

Both the elaboration and action plan reconstruction hypotheses provide convincing explanations for the contextual interference effect and, presumably, both are correct. It is interesting to note that both points of view highlight the increased attention and cognitive effort required of learners when practicing in random conditions compared to blocked conditions, as tasks to be performed constantly vary. Thus, a common thread in the elaboration and reconstruction hypotheses is that both suggest that contextual interference is a function of the increased cognitive effort prompted by high contextual interference and reduced cognitive effort resulting from low contextual interference.

An alternative perspective to the elaboration and reconstruction hypotheses that deserves to be mentioned is the ***implicit learning hypothesis***. This hypothesis provides an explanation of the contextual interference effect that derives from the theory of implicit motor learning. This type of learning refers to the acquisition of motor skills with a minimal awareness of the step-by-step processes underlying the actions, thus reducing reliance on memory. Motor skills are often acquired implicitly when performers execute without attempting to consciously analyse their movement patterns. During random/serial practice the cognitive resources to detect and correct errors can be so overwhelmed by the information required to switch tasks that learners are unable to concentrate on movement solutions or memorize rules and information related to the task. Therefore, random/serial practice can involve high levels of cognitive activity, but this activity is not directly assigned to the development of movement solutions.

In short, the implicit learning hypothesis concurs with the elaboration and reconstruction assumptions that high contextual interference evokes higher levels of cognitive effort than low contextual interference, but suggests that the cognitive processing caused by task switching can prevent learners from actively processing their previous movement solutions. In high contextual interference, the individual’s cognitive resources could be so engaged by the high demands of random/serial practice that conscious learning is prevented. Eventually, performers during high contextual interference learn more implicitly than performers involved in low contextual interference who have more attention capacity available for conscious interpretation and planning of their movements.

Implications for Practice

The well documented benefits of contextual interference during the acquisition of motor skills have strong implications for the design and implementation of training programmes. As a general guideline, coaches should arrange learning sessions according to random or serial schedules. The long-term benefits of contextual interference should outweigh the concerns about small improvements in the short-term performance of learners involved in random or serial practice.

An important question, however, is when to introduce high contextual interference during learning. The decision depends on a number of factors, such as the individual's age, experience, and ability level. With high contextual interference, novices can be overwhelmed by the high complexity of cognitive demands and movement coordination patterns required to accomplish the task. Random or serial schedules, in fact, present a greater immediate challenge for younger or less skilled learners who may not benefit from the effects of high contextual interference unless they have developed an elementary mastery of the skill. Therefore, acquiring new skills may require that tasks be presented in blocks for some time. More complex skills may entail a longer period of blocked practice before starting random or serial practice. The transition to random or serial schedules should take place as soon as the learner acquires a basic knowledge of the task and is able to approximate the movement patterns. In the second phase of learning (the associative/advanced stage), high contextual interference is more effective than low contextual interference.

PRACTICE VARIABILITY AND CONTEXTUAL INTERFERENCE: SCHEDULING ACTIVITIES

In order to create effective learning conditions, another important question for the coach is how to combine contextual interference with practice variability. As shown in Figure 2.5, skills can be practiced in a blocked or random/serial manner under constant or variable conditions.

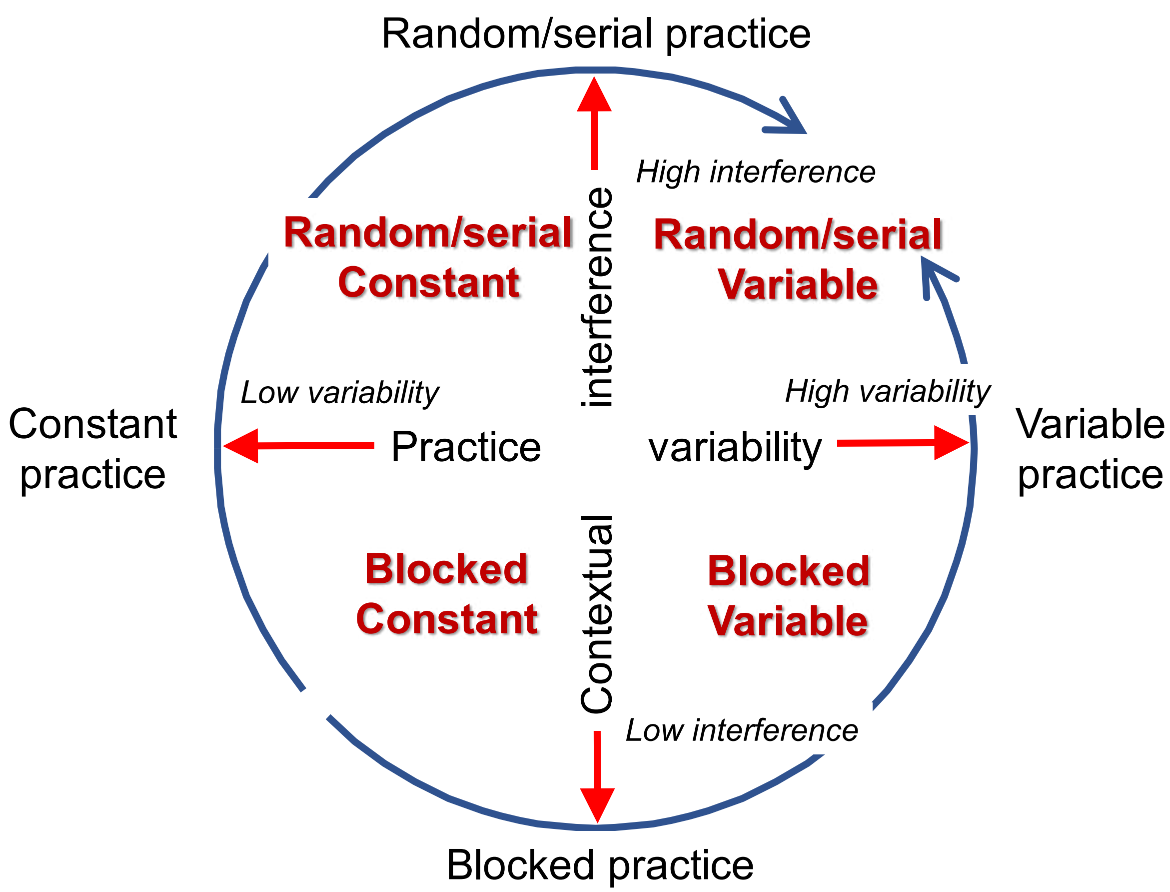

Figure 2.5. The relationship between variability of practice and contextual interference.

The blocked–constant practice represents the simplest condition that can be used in the first stage of the learning new skills or when teaching complex skills. In the more advanced phases of learning, practice can progress towards a random/serial–variable practice condition as indicated in Figure 2.5 by the curved arrows.

The way to organize the four types of practice is illustrated in Figure 2.6. The three hypothetical skills A, B, and C are executed in series of 12 repetitions without variations (blocked–constant practice), series of 12 repetitions with 3 variations of each skill (blocked–variable practice), series of 3 repetition of each skill in alternating order for a total of 12 repetition of each skill (serial–constant practice), and series of 3 repetition of each skill in alternating order with variations for a total of 12 repetition of each skill (serial–variable practice).

LOW INTERFERENCE

a) **Blocked–constant practice**
(series of skills A, B, C)

AAAAAAAAAAAA BBBBBBBBBBBB CCCCCCCCCCCC

b) **Blocked–variable practice**
(series of skills A, B, C with variations 1, 2, 3)

$A_1A_2A_3A_1A_2A_3A_1A_2A_3A_1A_2A_3$ $B_1B_2B_3B_1B_2B_3B_1B_2B_3B_1B_2B_3$
$C_1C_2C_3C_1C_2C_3C_1C_2C_3C_1C_2C_3$

c) **Serial–constant practice**
(series of skills A, B, C in alternating order)

AAABBBCCC AAABBBCCC AAABBBCCC
AAABBBCCC

d) **Serial–variable practice**
(series of skills A, B, C with variations in alternating order)

HIGH INTERFERENCE

$A_1A_2A_3B_1B_2B_3C_1C_2C_3$ $A_1A_2A_3B_1B_2B_3C_1C_2C_3$
$A_1A_2A_3B_1B_2B_3C_1C_2C_3$ $A_1A_2A_3B_1B_2B_3C_1C_2C_3$

Figure 2.6. Practice schedule designs varying from low to high contextual interference for three skills and three variations of each skill.

A hypothetical example in pistol shooting may involve practicing three skills, 15 repetitions each, in four conditions, as shown in Table 2.2. Examples of training variations of the "Lifting" skill aimed at stimulating balance consist in alternating pistol lifting with feet naturally spread apart, with feet together, and on one foot. Of course, the 15 repetitions suggested, or a given amount of time, is just to provide an example. The number of repetitions or the amount of time, as well as the skills practiced, can vary in function of the training time available, the training goals, and other individual variables (e.g., age, experience, skill level).

Table 2.2. Contextual interference and variability organisation: a hypothetical example with pistol shooting skills (rep = repetitions; var = variations).

Blocked–constant practice *The simplest condition*	**Blocked–variable practice** *A condition of intermediate difficulty*	**Serial–constant practice** *A condition of intermediate difficulty*	**Serial–variable practice** *The most challenging condition*
1) Lifting: 15 rep, no var 2) Sighting: 15 rep, no var 3) Triggering: 15 rep, no var	1) Lifting: 5 rep, var 1 5 rep, var 2 5 rep, var 3 2) Sighting: 5 rep, var 1 5 rep, var 2 5 rep, var 3 3) Triggering: 5 rep, var 1 5 rep, var 2 5 rep, var 3	1) Lifting: 5 rep, no var Sighting: 5 rep, no var Triggering: 5 rep, no var 2) Lifting: 5 rep, no var Sighting: 5 rep, no var Triggering: 5 rep, no var 3) Lifting: 5 rep, no var Sighting: 5 rep, no var Triggering: 5 rep, no var	1) Lifting: 5 rep, var 1 Sighting: 5 rep, var 1 Triggering: 5 rep, var 1 2) Lifting: 5 rep, var 2 Sighting: 5 rep, var 2 Triggering: 5 rep, var 2 3) Lifting: 5 rep, var 3 Sighting: 5 rep, var 3 Triggering: 5 rep, var 3
Total: 45 rep	***Total: 45 rep***	***Total: 45 rep***	***Total: 45 rep***

WHOLE AND PART PRACTICE

An important decision when teaching a new skill is whether it is better for the beginner to practice the technical skill in its entirety (i.e., the whole practice) or if it is preferable to break the technique into parts (i.e., part practice).

When the ***whole practice*** is used, the skill is usually briefly described or demonstrated and then performed as a whole, from start to finish. This method is particularly suitable for skills that cannot be easily separated into subparts. Practicing the skill as a whole helps the performer to get better feelings of flow, timing, and movement outcome, while practicing the skill in parts reduces the complexity of the task and allows a correct execution before the whole skill is put together. Whole practice is not suitable for complex or potentially dangerous skills (e.g., acrobatic tasks).

When learning complex skills, learners can feel overwhelmed by the difficulties associated with task execution. The inability to accomplish the task correctly can increase feelings of frustration, which can cause novices to withdraw from practice. As a result, ***part practice*** is often used as an instructional strategy aimed at reducing the demands of the task. An otherwise complex skill is presented in a more simplified form to enable learners to experience success and improve further.

Two aspects of a skill can be considered when deciding whether to practice the task as a whole or in parts: Task complexity and task organisation (Figure 2.7).

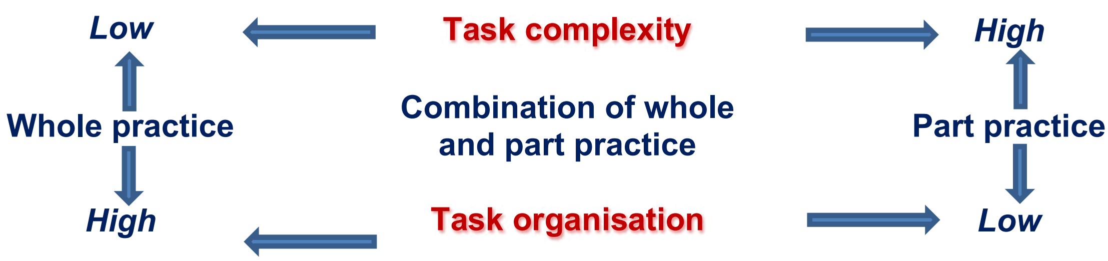

Figure 2.7. The relationship of task complexity and task organisation to whole and part practice.

Task complexity refers to the number of parts or components of a skill and to the cognitive demands of the task. These include the level of attention needed to perform (attention demands) and the number of parts to remember (memory demands). A very complex skill, like a gymnastics routine, is composed of many parts and requires a high level of attention especially for a beginner, while a low complex skill, such as throwing a ball, is made of few components and requires relatively little attention. It is important to distinguish complexity from difficulty. Lifting a heavy barbell off the floor can be very difficult although the task is fairly simple.

Task organisation refers to the relationship between the components of the task. A dance routine has a relatively low degree of task organisation because the order of the elements can change. On the other hand, the organization of the movements in clay target shooting is very high because the parts of the actions are dynamically related to each other through a common spatiotemporal pattern inherent to the whole skill. For example, the shouldering of the gun in skeet requires to concurrently lift the gun and rotate the body in the direction of the target. As such it is an organised (and complex) set of individual actions that are performed simultaneously.

Applying the Principles

As a general rule, whole practice is recommended when the skill is low in complexity and high in organisation. On the contrary, part practice can be the best choice when the task is highly complex and little organized. However, it is often difficult to apply this rule because not all skills can be categorized into one side or the other of the continuum of complexity and organization. Some skills, indeed, fall into the middle of the continuum and may therefore require a combination of whole and part practice (i.e., learning skills as a whole at times, and in part at other times), or progressive part practice in which the parts are gradually chained together.

A related (mixed) method is the ***whole-part-whole practice***. The learner first tries to perform the entire task to get the feel of whole performance and to establish the easy and difficult elements. The coach then extracts the difficult parts and the performer practices them before putting them back into the whole performance.

It is important to emphasize that in highly organized and very complex skills, such as those of shooting sport disciplines, the parts cannot be separated without losing some essential coordinative characteristics. Coaches can use part practice with beginners to better focus their attention on specific elements of the action and seek accurate execution. When learners reach a solid understanding of the components of the action, the parts can be reassembled using whole practice.

Therefore, parts can be practiced separately and then joined together to form the complete action. With this method, called ***segmentation***, the shooting technique is broken down into components (or segments) to be practiced separately until reaching a level of proficiency. The individual parts are then assembled together, and the shooting practiced as a whole.

Alternatively, the ***progressive part practice*** (or forward chaining method) is a useful way to integrate the parts into the whole. The shooter can start practicing the first part of a technique, then move on to the next part of the technique to practice it together with the first part. The shooter continues proceeding through each part of the technique until the entire technique is performed. Shooters can also start with the final part of the action and then add parts backwards, thus working towards the beginning of the technique (this method is called backward chaining).

Whatever the part practice method used, it is important to help learners understand how the individual components of the technique they are executing relate to the whole technique that represents the goal of the training.

Another method, called ***attentional cueing***, is to ask the shooter to execute the entire action but focusing only on one aspect of the technique including: (a) position elements (feet, legs, pelvis, limbs, etc.), breathing, aiming, and triggering; (b) movement dynamics (i.e., rhythm and speed); and (c) specific details in the visual field (e.g., wind flags). This method is more suitable for skilled athletes. Performers who are learning the fundamentals of the action may find difficult to focus on only one aspect.

The whole shooting action can also be simplified. ***Simplification***, for example, can be carried out by slowing down the shooting action so to allow the learner to pay more attention to specific technical aspects or to the relevant environmental cues. As soon as the benefits of reducing movement speed are evident, the whole action must be performed at the optimal speed.

SUMMARY

Practice is the most important factor in learning motor skills. However, beyond the quantity of the practice, the quality of the practice is fundamental for improving learning. Designing effective training programmes requires the application of a number of instructional principles.

Massed and distributed practice. For discrete skills, such as shooting techniques, a distributed practice *between sessions* promotes higher learning, while massed practice *within a session* is more effective. However, distributed practice within a session can be effectively used to insert periods of demonstration, observation, instructions, reflective thinking, self-evaluation of performance, and imagery.

Constant and variable practice. Variable practice of a single skill enhances the individual's ability to perform in a variety of ways and environmental contexts. However, constant practice can be useful when the task is highly complex or during the early stage of learning.

Blocked and random/serial practice. Variability of practice (random and serial) among several skills leads to better long-term learning. The contextual interference effect may seem a paradox, because a random or serial practice schedule can be detrimental during acquisition but have a positive long-term effect on learning. With beginners or when teaching complex skills, however, a period of blocked presentation may be necessary before moving to a random or serial schedule. The beneficial effects of random/serial practice over blocked practice can be due to several factors. Random practice:

- compels the learner to engage more actively in the learning process by preventing simple repetitions of actions;
- creates in the learner more significant and distinguishable memories of the various tasks, increasing memory strength and decreasing confusion between the tasks;
- causes the learner to forget short-term solutions to the action problem after each task change and forces the regeneration of the solution in the next trials of the task, which is beneficial for learning.

Whole and part practice. Practicing the skill as a whole allows the performer to get better feelings of flow, timing, and outcome associated with the action. When the technical skill is too complex for the learner, other methods can work better. These include the *whole-part-whole practice*, *segmentation*, *progressive part practice* (forward and backward chaining methods), *attentional cueing*, and *simplification*.

In applying these principles of practice, coaches must keep in mind the distinction between short-term performance and long-term learning. Instructional strategies should focus on long-lasting achievements rather than immediate performance. Particular attention must be paid to the features of the task (such as difficulty, complexity, and organisation) and to the characteristics of the learner, including age, experience, motivation, and abilities.

Suggested Readings

Abraham, A., & Collins, D. (2011). Effective skill development: How should athletes' skills be developed? In D. Collins, A. Button, & H. Richards (Eds.), Performance psychology: A practitioner's guide (pp. 207-229). Edinburgh, UK: Churchill Livingstone Elsevier.

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Wright, D. L., Sekiya, H., & Rhee, J. (2014). Organization of practice. In A. G. Papaioannou & D. Hackfort (Eds.). Routledge companion to sport and exercise psychology: Global perspectives and fundamental concepts (pp. 289-307). New York, NY: Routledge.

Self-Evaluating Questions

- Define massed and distributed practice.
- What factors should be considered when deciding to use either a massed or a distributed practice schedule within a practice session?
- What are the relative benefits of massed and distributed practice over several practice sessions?
- Define constant and varied practice.
- What factors should be considered when deciding whether to use constant or varied practice?
- Define contextual interference, and describe how it is related to blocked, serial, and random practice.

- Define and explain the differences between blocked, serial, and random practice schedules.
- In general, what are the effects of blocked and random/serial practice schedules on immediate performance and long-term learning?
- When and how should random/serial practice be introduced into a practice schedule?
- Identify reasons why contextual interference benefits motor skill learning.
- How can practice variability and contextual interference be combined in planning the training sessions?
- Describe when it is preferable to use part practice or whole practice in learning of motor skills.
- What is intended with whole-part-whole practice, practice segmentation, progressive part practice, attentional cueing, and simplification?

Practical Activities in the Field to Apply Instructional Principles

- Use instructional strategies based on the distribution of practice principle to help your novice shooter learn a technical skill.
- Identify a basic technique in your shooting discipline and drawing on the practice variability notion apply several variations of the skill to improve learning of your shooter.
- Choose three technical components of your shooting discipline and apply a serial schedule in a training session with your shooter.
- Select three technical components of your shooting discipline and three possible variations. Then apply a serial–variable schedule in a training session with your shooter.

- Use the four types of training schedules deriving from the combination of the variability and contextual interference principles (i.e., blocked–constant, blocked–variable, serial–constant, serial–variable) to design four training sessions aimed at improving shooting skills. Then, ask one of your shooters to experience each situation:

Blocked–constant practice	**Blocked–variable practice**	**Serial–constant practice**	**Serial–variable practice**
Total repetitions or time:	Total repetitions or time:	Total repetitions or time:	Total repetitions or time:

- Apply some technical drills with your shooter using each of the following methods: whole-part-whole practice, practice segmentation, progressive part practice, attentional cueing, and simplification.

Power Point Presentation

Slides 26 to 43.

CHAPTER 3 – IMPROVING PERFORMANCE THROUGH MENTAL PRACTICE

OVERVIEW

Mental practice, also known as motor imagery practice, is the systematic application of mental imagery for the cognitive rehearsal of a task (i.e., the representation of a given motor movement) in the absence of overt physical movements.

Humans create mental images for a multitude of purposes. When used properly, imagery can be a powerful process in improving athletic performance. It has been found to enhance self-confidence, motivation, attention focus, performance, and learning new skills, and it is adopted as a method to reduce competitive anxiety, psych up for training or competition, and develop competitive plans and strategies. Most successful athletes use it!

In his book “With winning in mind”, Lanny Bassham, famous world and Olympic medallist rifle shooter, wrote the following:

> Back in the 1970s, I was shooting good kneeling scores and began approaching the national record of 396/400. I wanted to set the record at 400, a perfect score. But I had never actually fired a 400, even in training. Nonetheless, I vividly rehearsed shooting the first 100, then another and another. I visualized each of the last ten shots building toward the record. I rehearsed what I knew would happen at the point: I would realize that I was above the record. Next, I rehearsed hearing a voice say, “That’s OK, I do this all the time,” Then I imagined shooting the final ten easily and saying to myself, “Another 400, that’s like me!” I rehearsed this sequence several times a day for two months. In my first competition since beginning the rehearsal, I started with a 100 kneeling. My next two targets were also 100s. I began my last series with ten, ten, ten, ten. Only five more to go. Ten. Ten. Ten. Then reality set in. I was above the record. I heard an internal voice say, “That’s OK, I do this all the time.” I shot two additional tens, setting the national record at a perfect 400. (Chapter 7, 2011)

Motor imagery can be external, from the perspective of a third person like watching oneself in a movie, or internal, from the perspective of the performer like seeing with the own eyes. In addition, imagery in sport can involve a variety of senses, including visual, auditory, tactile, olfactory, and kinaesthetic senses.

As clearly shown by neuroscience studies, when people create mental images the parts of the brain that are responsible for actual physical movement increase their activity. When performers at rest imagine a complex movement, their brain areas responsible for motor activity, sensory perception, proprioceptive feedback, and motor control show activation. Muscular contraction is also observed in those segments of the body involved in the imagined action.

Motor imagery promotes learning and performance improvement through cognitive, neurological, and muscular activation. The brain cannot discern the difference between a real physical event and the vivid imagery of the same event. A vivid imagery can be thought as a dream or daydream in which the experience is so intense that it is perceived as real. For this reason, performers can used imagery to repeat, elaborate, improve, and maintain technical skills, as well as prepare for competition.

INTRODUCTION

Motor imagery can be defined as a dynamic state during which performers simulate specific motor actions mentally, typically without physical movement, and generate and transform the image in order to rehearse an action for performance or learning effects. A performer creates or recreates experiences based on memorial or newly generated information and in the absence of the actual sensory stimuli.

In particular, a mental representation can be created in the mind in the absence of external stimuli, can involve one or more physical senses, and is created from information stored in memory. Research indicates that when individuals engage in a vivid and multisensorial type of imagery, their brains can interpret these images as identical to the actual stimuli of the situation and determine similar bodily and muscular responses.

Motor imagery is a skill that can be developed and improved like any other. Athletes, coaches, and practitioners often use different terms that refer to an athlete's motor imagery, including mental practice, mental preparation, visualization (a term commonly used by athletes and coaches), mental rehearsal, cognitive rehearsal, symbolic rehearsal, and covert practice. Although not synonymous, these terms imply a mental creation, rehearsal, or recover from the memory of an experience.

There is clear evidence to support the beneficial effects of images regardless of individual skill levels and the type of sport practiced. This evidence comes from anecdotal reports, case studies, and scientific experiments that clearly demonstrate the value of imagery in learning and performing motor skills, and in preparing for competition.

For applied purposes, it is useful to consider the ***4 Ws of motor imagery*** (see Table 3.1). The *where* and *when* of imagery use regard the specific situation (e.g., practice or competition). The *why* of imagery use refers to motivational or cognitive/behavioural purposes (e.g., changes in skill execution or strategy). The *what* of imagery use refers to the nature and content of the images.

Table 3.1. The 4 Ws of motor imagery.

Where do athletes image? Most of the use of imagery occurs in practice and competition, with athletes using imagery more frequently during pre-competition. Athletes should be instructed to use appropriate imagery before and during training and competitive events.
When do athletes image? They use or could use imagery: (a) before, during, and after practice; (b) outside of practice (home, school, work); (c) before, during, or after competition; and (d) during injury rehabilitation.
Why do athletes image? To enhance their motivation (e.g., imaging themselves winning an event and receiving a medal) or to improve their performance (e.g., imaging themselves performing a perfect shot).
What do athletes image? They image or could image the environment in which performance takes place and optimal performance outcomes. They should involve in imagery the main senses (i.e., visual, auditory, tactile, and kinaesthetic) and form a good, clear, controllable image, regardless of whether it is from an internal (i.e., from the own vantage point) or an external perspective (like watching a movie).

Athletes can therefore use imagery in various ways to improve both physical and psychological skills and attitudes, including concentration, motivation, confidence, emotional control, sport skills and strategies, preparation for competition, coping with pain or injury, and problem solving. Imagery, of course, does not replace physical practice unless the performer is injured, fatigued, or over-trained. Imagery is usually combined and integrated with physical practice to enhance the effects of physical training.

Beyond the 4 Ws of imagery, an additional question is: How does imagery work? Table 3.2 contains the main perspectives proposed to explain the beneficial effects of imagery on performance. Although the characteristics of images have specific effects for each individual, effective images have two key aspects: vividness and controllability. These can be improved with practice.

Vividness involves the use of the most important senses to make images as vivid and detailed as possible and close to the real experience. Particular attention should be paid to environmental details and to the experience of emotions and thoughts that occur during training and competition. Experiencing concentration, anxiety, frustration, excitement, and other feelings and emotions associated with performance will make the imagined performance more real.

Controllability refers to the ability to manipulate the own images at will. This characteristic is important for creating an accurate and successful execution of the skill in mind. Seeing oneself performing perfectly and achieving best outcomes boosts self-confidence and augment the chances of success.

These characteristics are incorporated in the PETTLEP model.

Table 3.2. Different perspectives to explain imagery effectiveness.

Psychoneuromuscular theory

When performers image themselves moving, their brains send subliminal electrical signals to the muscles in the same order as when actual movement occurs. Electrical signals, in particular, determine which muscles should contract, when and with what intensity (similar neural pathways to the muscles are used). It is through this mechanism that imagery can aid skill learning.

Symbolic learning theory

Imagery helps the brain develop a blueprint of the action (movement pattern or plan) that can be followed when action is required.

Bioinformational theory

Based on the assumption that an image is a functionally organized set of propositions stored in the brain, the bioinformational theory holds that a description of an image consists of two main types of statements: stimulus and response propositions. Stimulus propositions describe specific stimulus features of the imagined scenario, while response propositions describe the individual's response (i.e., physiological reactions) to the scenario.

Triple code model

The model focus on three effects referred to as ISM that are essential parts of imagery. The first is the image (I) itself, which represents the outside world and its objects with a degree of sensory realism. The second is the somatic response (S), namely, the psychophysiological changes in the body (e.g., muscular tension, changes in breathing patterns, increased heart rate, sweating). The third is the meaning (M) of the image. Every image, or sequence of images, has a particular meaning for each individual.

Psychological perspective

Imagery helps develop psychological skills that are critical for performance improvement. It increases confidence, motivation, concentration, and decreases anxiety. Imagery also helps the athlete achieve an optimal level of activation (arousal) and to focus attention on task-relevant cues, thereby priming the athlete for performance.

THE PETTLEP MODEL

Athletes with a higher imagery ability will benefit most from the use of imagery. However, the use of structured and evidence-based imagery techniques, such as those described in the PETTLEP model, will help athletes achieve vivid and effective imagery.

Based on research findings in sport psychology and cognitive neuroscience, Holmes and Collins (2001) developed the PETTLEP model (or method) to produce functionally equivalent mental simulation of actions and to determine the behavioural matching between imagery and action (Wakefield, Smith, Moran, & Holmes, 2013). PETTLEP is an acronym, with each letter standing for an important practical aspect to consider when implementing imagery interventions: Physical, Environment, Task, Timing, Learning, Emotion, and Perspective (Figure 3.1).

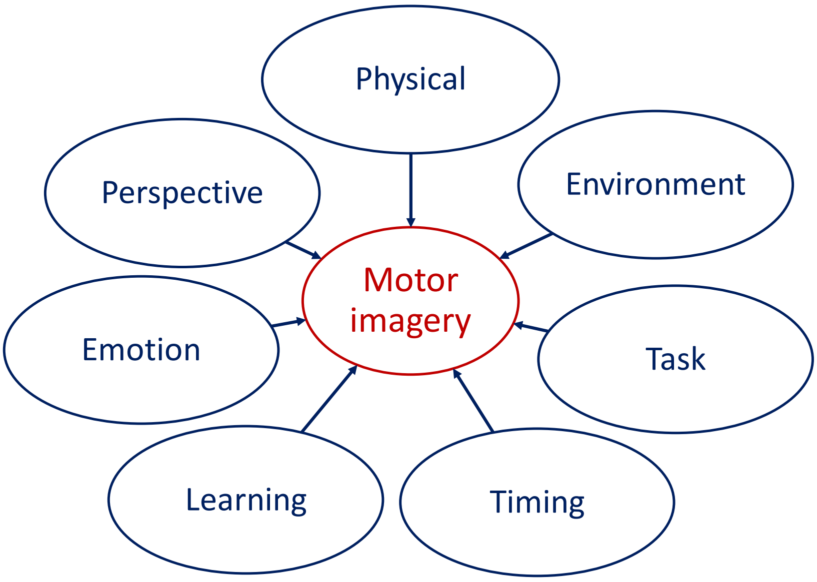

Figure 3.1. The PETTLEP model.

The PETTLEP guidelines are intended to closely replicate the sporting situation through imagery, including physical and emotional feelings associated with performance. The seven key elements of the model must be considered and applied as fully as possible to make imagery most effective.

Traditional imagery methods have often been thought of as something separate from physical practice. The PETTLEP approach, on the contrary, conceptualizes imagery and physical practice as a continuum. Imagery interventions, to be effective, should be as close as possible to the physical end of the continuum.

The ***Physical*** component refers to the athlete's physical experience in the sport situation. Rather than using imagery in a relaxed and undisturbed state, which is in complete contrast to the athlete's physical state during performance, athletes should imagine the movement in the same way the action is carried out. This physical approach to imagery interventions should include a range of physical sensations. In rifle shooting, for example, physical sensations involve bodily (e.g., muscle tension, breathing, and heart pounding) and tactile feelings while keeping the kneeling position and holding the rifle. The shooter should also wear the same clothes as when performing. In this way the athlete recreates as much as possible the physical experience associated with the actual execution in order to generate a realistic imagery experience. Coaches should examine in detail which bodily sensations are most relevant to the individual athlete, and then try to actually reproduce these feelings to incorporate them as much as possible in the scenario to be represented.

The ***Environment*** component refers to the place where performance takes place. Before competition, for example, the imaginary environment should be the same or as similar as possible to the location (e.g., the competitive shooting range) where performance will take place. If this is not possible, photos, videos, and audios of the venue can be useful in helping athletes familiarize themselves with the competitive arena. Shooters, for example, may visit the range prior to competition and observe light and wind conditions at a certain time of day.

The imagined ***Task*** must be closely matched to the actual one. Images should contain same thoughts, feelings, and actions present during physical execution. In addition, the imagery content (i.e., thoughts, feelings, and actions) should be appropriate to the skill level and individual preferences. To achieve behavioural matching between imagery and action, the imagery content should be different for elite and inexperienced performers. This is because skill levels, and therefore the specific skills that are imaged, are different. As novices improve, it will be necessary to change the content of images based on individual changes.

The ***Timing*** component refers to the pace (rhythm, speed) at which the imagery is completed. Sometimes it may be useful to slow down or stop the movements to focus on correcting errors, changing specific technical aspect, or the feelings of the action. This type of practice, however, should be limited because the precise timing is an essential feature in skill execution. In most cases, imagery must be completed at the same pace at which the action is executed, as techniques are rarely performed in slow motion or faster than normal.

In the ***Learning*** component, the individual's skill level is considered. The content of the imagery should be adapted in relation to the learning stage. To retain the behavioural matching between imagery and the action it is necessary to follow the athlete's progress and, therefore, regularly review and update the content of the imagery. Imagery training should reflect physical training according to the developments in actual technique.

The ***Emotion*** component refers to the emotional state included in the imagery. All feelings, emotional states, and arousal experienced during optimal performance should be mentally recreated during practice to make imagery realistic. Including realistic emotions in imagery makes the mental experience much more evocative, thus leading to a more vivid imagery experience.

Finally, the ***Perspective*** component refers to the viewpoint of the performer during imagery. Imagery can be internal (first person, through the eyes of the performer) or external (third person, seeing oneself performing as if watching on a video screen). For a behavioural matching between imagery and action perspective, internal imagery is preferable because more closely related to the athlete's view during the execution. However, external imagery can also be beneficial. Indeed, advanced performers are able to switch from one perspective to another and take advantage of both perspectives in terms of imagery experience and performance. For successful interventions, it is important to consider individual preferences regarding the imagery perspective.

It is important to remember that imagery can be a feasible alternative to physical practice in situations where physical practice is not possible, such as when the athlete is exhausted or injured. However, under normal conditions a combination of physical practice and imagery is more effective than either method alone. It is therefore recommended to use physical practice as integrated as possible with imagery practice, according to the indications stemming from the PETTLEP model.

The different components of the model should be progressively implemented in the athlete's mental preparation. This is to avoid the possibility of overloading the athlete with too much new information and to evaluate the effectiveness of each component of the model for the individual.

The key recommendations based on the PETTLEP model together with applications in shooting sports are summarised in Table 3.3.

Table 3.3. Key recommendations for implementing the PETTLEP model with applications in shooting.

Component	Recommendation	Practical examples
Physical	Replicate in imagery all the physical sensations experienced during the actual performance.	Imagine shooting while holding the gun and wearing your shooting gear.
Environmental	Imagine the environment where actual performance will take place.	Standing in front to the target, imagine the shot prior to execute. Use photos, videos, and audios if you are out of the range.
Task	Imagine performing with the same thoughts, feelings, and actions present during physical execution.	Mimic the precise elements of the shooting skills to improve.
Timing	Imagine performing with same speed and pace of the actual task (i.e., synchronise the mental task with the physical task).	Imagine a series of shots performed at constant optimal speed (i.e., within shot consistency) and pace (i.e., between shot consistency).
Learning	Change the content of imagery over time based on the improvement of skills that occur during the learning process.	Update your imagery on shooting to reflect the specific techniques you are working on. Focus on the more refined elements of the technique as you become more proficient.
Emotion	Imagine and relive the same emotions associated with the physical execution of the task.	Include all emotions associated with your optimal shooting performance, including bodily reactions such as muscular tension and heart rate.
Perspective	Preferably use an internal visual perspective, although either an internal or external point of view can be functional to your goals and preferences.	Imagine shooting a series from an internal perspective. If you want to correct errors or refine performance, you may use an external perspective to imagine directing your visual attention to the technical aspects.

PERFORMANCE ROUTINES

Indications from the PETTLEP model can be incorporated into performance routines. A performance routine is a well-planned course of relevant thoughts and actions that enable an athlete to focus and perform better, almost automatically. The primary goal of a performance routine is to help the athlete achieve an optimal internal state in order to express maximum potential. To meet this goal, a routine can include a series of techniques designed to self-regulate the level of activation (arousal), thoughts, and attentional focus. A routine can act as a protective frame against the adverse effects of pressure, because performers can keep their attention on what they control. Experienced athletes who regularly perform closed motor skills, also referred to as self-paced skills, use performance routines consistently.

As discussed in Chapter 1, ***self-paced skills*** are those skills that take place in relatively stable and predictable settings, where sufficient time is available before execution. Examples are free throws in basketball, golf strokes, tennis or volleyball serves, penalty kicks in soccer or rugby, springboard or platform diving, track and field events, as well as shooting sports. Pre-shooting routines are frequently observed among elite level shooters.

The use of preparatory routines relevant to the task allows athletes to: (1) establish the action plan before performing; (2) focus attention, stay focused, and overcome external distractions (e.g., noise generated by the audience) and negative internal thoughts (e.g., "I am going to miss this shot"); and (3) feel in control of their performance.

It is important to recognise the difference between routines and superstitious behaviours or rituals. For example, an athlete may wish to wear the same socks worn during a previous victory or have the same meal before each competition. These behaviours may seem routines, but they are most likely superstitions. Routines are not compulsive and have nothing to do with luck. They are useful, flexible, effective, and aimed at improving focus and performance. The athlete controls them. In contrast, superstitious behaviours have little to do with focus and a lot to do with luck. They are compulsive, rigid, and ineffective, and the athlete does not control them. A routine can become compulsive when the athlete believes that a certain behaviour must be executed in a very specific and rigid way in order to perform well. The focus, then, is on superstitious behaviour, which completely distracts from performance. Athletes must be aware of the difference between routines and superstitions, and therefore focus on controllable and effective behaviours.

THE FIVE-STEP STRATEGY

The five-step strategy was developed by Singer (1988, 2000) as a systematic and flexible routine to be used before, during, and after performance of self-paced skills. The five-step strategy has proven to be particularly useful in the learning process, as well as in facilitating skilled performance in numerous laboratory and field studies.

The strategy contains five sub-strategies:

1) ***Readying—***Establishing an optimal physical and mental set. This implies reaching an optimal bodily and mental condition in terms of confidence, expectations, attitudes, and emotions. Self-talk and arousal regulation techniques can be applied (arousal regulation is discussed in the next Chapter). The performer may attempt to repeat what previously led to excellent performance.
2) ***Imaging—***Mentally picturing a perfect technique, how it should be done, and a successful outcome. The indications deriving from the PETTLEP model are particularly useful for the development of vivid and effective images.
3) ***Focusing—***Concentrating attention intensely on a relevant cue related to performance. This point is elaborated below in the "Identifying the core components of the action" section.
4) ***Executing—***Performing with a quiet mind, with a 'just do it' mindset. The performer must avoid thinking about the act itself or the possible outcome.
5) ***Evaluating—***Reviewing the execution quality and the outcome. If time permits, also evaluating the implementation of the previous four phases of the routine to adapt the next execution and/or the strategy when necessary.

The strategy can be used to facilitate learning of motor skills, as well as to maintain good performance under pressure. Novice shooters can apply the five-step strategy in practice sessions before, during, and after a single shot or a series to improve their technical learning. More advanced shooters can refine the five-step strategy during training and then apply the routine in competition.

Wilson and Richards (2011) suggested a slight modification of the strategy to make it more adaptable to pressure situations that expert performers encounter in competition (see Figure 3.2). The main goals are to:

1) ***prepare*** for an optimal performance state. This includes both readying and imaging steps;
2) ***perform*** in an instinctive-like manner. This encompasses both focusing and executing to create the a 'quiet mind' associated with unconscious performance;
3) ***review*** and evaluate performance to obtain feedback for subsequent attempts. It is important to emphasize that the performer must refocus rather than dwell on the possible mistakes made.

Performance routines must be applied systematically to achieve consistent performance. However, it is the mental state before and during performance that should be consistent, not the behaviours linked to the routine. Behaviours and associated mental activity should be used flexibly depending on the individual's mental state and possible differences from an optimal performance condition. Therefore, performers should develop a reliable and flexible routine that can be effectively adapted to the current situation.

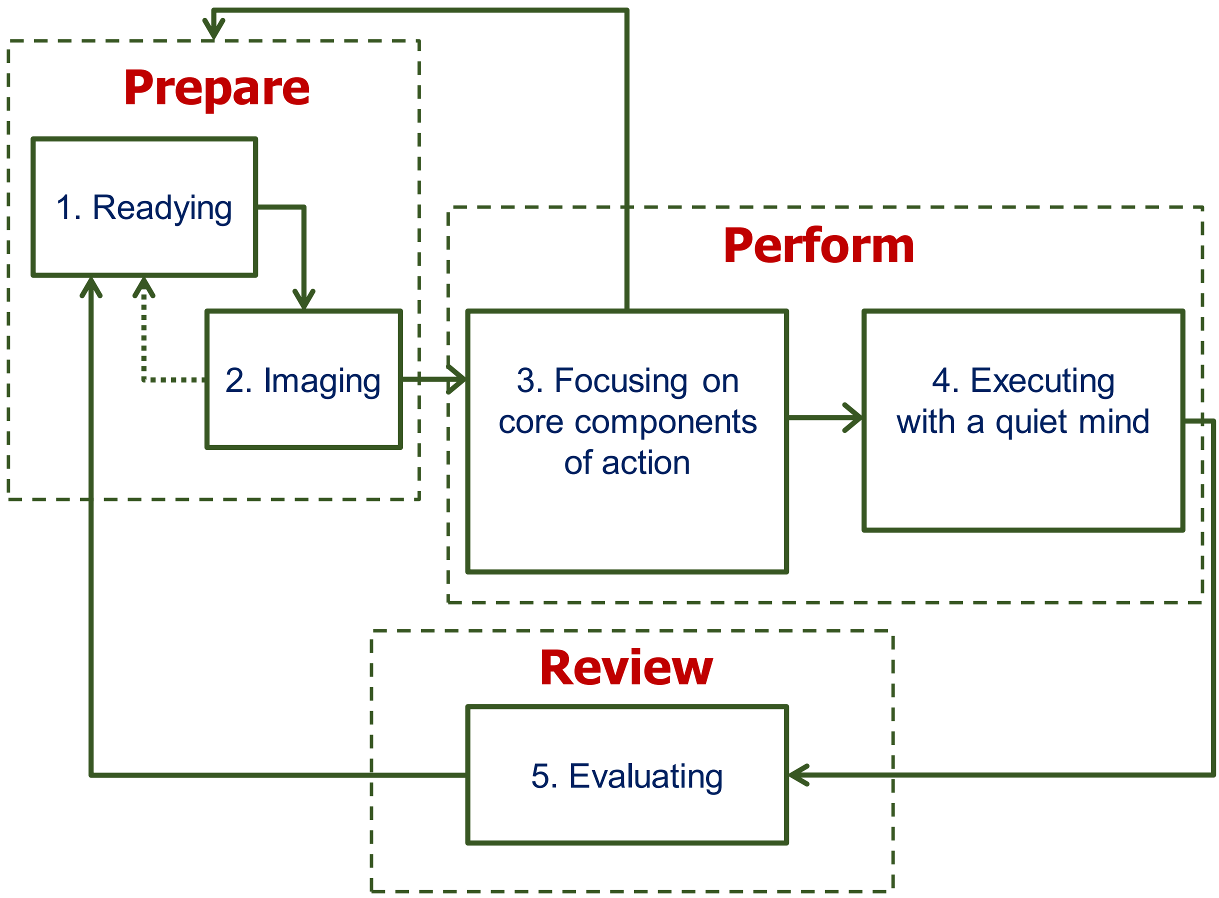

Figure 3.2. The Singer's (2002) five-step strategy adapted by Wilson and Richards (2011) and further modified to include the core components of the action in the third step (i.e., focusing attention).

IDENTIFYING THE CORE COMPONENTS OF THE ACTION

Directing attention to a few "core" components of the action allows the athlete to execute a movement pattern within a functional range of variability, and therefore to perform more consistently, in particular under competitive pressure. Core action components are conceived as fundamental movements or action-related behaviours not always executed in a fully automated mode. Examples in the shooting disciplines are "positioning", "grip", "aiming", "timing", and "rhythm". These core components can exhibit higher variability and accuracy fluctuations compared to automated technical elements, which are typically executed without conscious attention. Therefore, they should not be confused with those technical fundamentals that are usually largely automated. Core action components are encoded and stored in long-term memory and determine the effectiveness of movement patterns. Their mental representations are idiosyncratic, and therefore differ widely among athletes. Attention to core components tends to improve movement mastery and self-confidence in practice and competition.

Action core components are a central notion in the so-called multi-action plan (MAP) model (Bortoli, Bertollo, Hanin, & Robazza, 2012; Robazza, Bertollo, Filho, Hanin, & Bortoli, 2016). According to the MAP model tenets, performance levels (optimal and suboptimal) are classified based on action monitoring/control levels (see Figure 3.3).

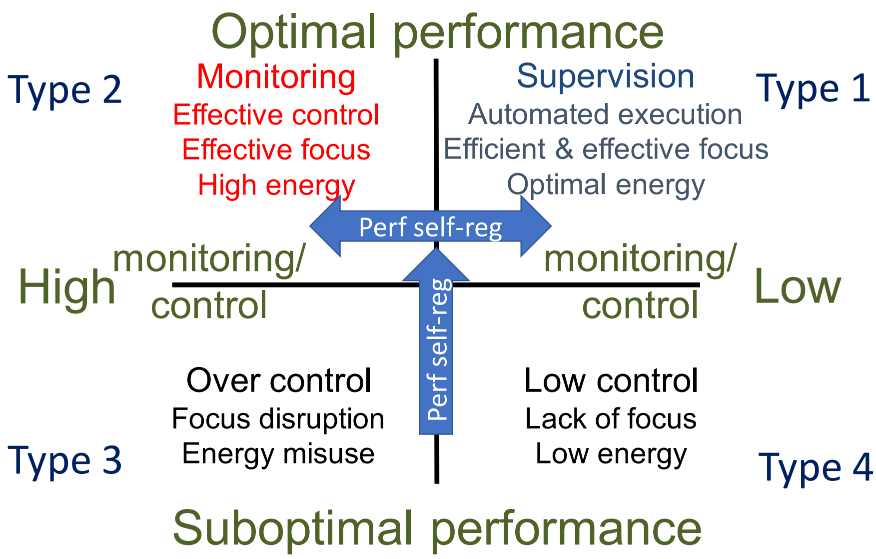

Figure 3.3. The interaction between performance and action monitoring/control levels according to the multi-action plan (MAP) model (perf self-reg = performance self-regulation).

This interaction between performance and monitoring/control levels gives rise to four performance states:

1) ***Type 1, optimal-automated performance state*** (i.e., action "supervision"), in which high performance is achieved with a low focus of attention aimed at "supervising" the correct flow of movement;
2) ***Type 2, optimal-controlled performance*** (i.e., action "monitoring"), in which high performance is achieved through attention focused on the core component(s) of the action to prevent step-by-step control of the movement and ensure that the action is properly executed;

3) ***Type 3, non-optimal-controlled performance*** (i.e., "over control" of action) with excessive attention to action control;
4) ***Type 4, non-optimal-automated performance*** ("low control" of action), with unfocused attention.

In Type 1 state ("supervision"), high-level performance is associated with low action monitoring/control. This is an ideal state where performance appears to be autonomous, effortless, smooth, consistent, and effective. The performer feels in complete control, confident, and energetic. However, this ideal state is rarely reached, and when experienced it can quickly vanish. Type 2 state ("monitoring") is experienced more frequently, especially under competitive pressure, and is characterized by an intense focus of attention directed voluntarily towards a limited number of action components. To achieve or regain a Type 2 state, attention should be directed to the core action components, so as to prevent excessive reinvestment or distraction of attention from task-relevant cues and also facilitate the transition to a more autonomous execution.

Types 3 and 4 states arise under stress or because of unpredictable difficulties that cause task disruption or disengagement. In Type 3 state, the performer's attempts to cope with situational demands or to recover from poor performance lead to distraction from task related cues, an excessive reinvestment of attention to the execution of automated skills, loss of energy, and worsened movement fluidity and automaticity. Finally, in Type 4 state performers show reduced commitment, little energy to achieve the goal, and unfocused attention. For example, an overconfident athlete may overestimate the current situation by anticipating victory before the competition ends, and therefore may mobilise less energy or resources than those necessary to perform well. Another athlete may feel relieved from competition pressure after making a mistake perceived as irreparable, and thus may decrease effort or disengage from the activity.

Athletes can self-regulate their performance states by focusing attention on the core components of the action. In this way they can maintain or regain optimal performance. A four-step procedure is proposed to help shooters identify the main components of the action to be used in training and competition.

In the first step the shooter is asked to describe in detail the usual optimal movement sequence (i.e., the chain of actions) of a single shot from start to follow-through. Among the sequence leading to optimal performance, a pistol shooter may report directing attention to body balance and alignment, handgrip, breathing, arm rising, gun and sight alignment, trigger pull, and follow-through. The sequence of movements is very individual and therefore can differ widely from one performer to another.

In the second step, the shooter is asked to select those elements (i.e., the core components) of the chain of actions considered fundamental for optimal performance and, at the same time, not always executed in a fully automated mode. The specific question is:

> Imagine yourself performing in a mentally or physically challenging condition or nonoptimal state—for example, when you are under distress or fatigue or after a mistake or a poor execution. What are the actions or behaviours that you consider fundamental to reach or maintain good performance and that you need to control intentionally to execute in a consistent and accurate manner?

It should be explained to the shooter that the main components refer to some (two or three) fundamental actions or shooting elements which tend to be unstable, and therefore unreliable if not controlled, especially in difficult situations.

In the third step, the expected functional effects on shooting performance derived from the attention directed to the core components must be verified during training.

In the final step, the core components should be checked in competition. The whole procedure should be repeated when the identified components are or become completely automatized and therefore do not need to be voluntarily controlled. In this case, new core components of the action should be identified.

SUMMARY

Mental practice, or motor imagery, is the most widely used psychological skills training technique for athletes. It has been used effectively for many purposes. Beneficial effects include increased self-confidence, motivation, attention, performance, learning, as well as reduction in competitive anxiety and debilitative emotional states.

It is therefore important to examine the *4 Ws of imagery* applied in sport. The *where* and *when* regard the situation in which imagery is used, the *why* refers to motivational or cognitive/behavioural purposes, and the *what* refers to the nature and content of the images. It is also important to examine *how* imagery works. Different theoretical views have been proposed to explain imagery effectiveness in sport, including psychoneuromuscular theory, symbolic learning theory, bioinformational theory, triple code model, and psychological perspective.

To be effective, images must be vivid and controllable. These characteristics are included in the PETTLEP model. The acronym PETTLEP represents the seven elements of the model: Physical, Environment, Task, Timing, Learning, Emotion, and Perspective. These aspects should be considered when implementing imagery programmes.

The PETTLEP model indications can be incorporated into the five-step strategy, a performance routine specifically designed to improve the learning and performance of self-paced skills, with a focus on preparation, performance, and review. The strategy contains five sub-strategies: (1) Readying, (2) Imaging, (3) Focusing, (4) Executing, and (5) Evaluating. In the third step (i.e., focusing), attention should be directed to the core components of the action identified and tested in training and then in competition. The strategy can be slightly modified to be properly adapted to competitive situations. Mental practice and performance routines need to be strictly individualized to meet the athletes' characteristics and needs. They must be practiced during training before being used in competition. Like technical skills, mental skills and routines require extensive practice to be acquired, developed, and then applied under pressure.

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Self-Evaluating Questions

- How can motor imagery be defined?
- Describe how imagery can be used for different purposes.
- Explain the application of imagery to help athletes achieve their goals.
- Describe the 4 Ws (i.e., where, when, why, and what) of motor imagery.
- What are the main theoretical perspectives to explain imagery effectiveness?
- What are the key aspects of effective motor imagery?
- What is the difference between external and internal imagery and how can athletes use each perspective?
- Describe the seven elements of the PETTLEP model.
- Explain why a performance routine can help the athlete perform well.
- What are the core components of the action?
- How can the core components of the action be identified?
- Why should the core components of the action be included in a performance routine?

Practical Activities in the Field to Apply Mental Practice and Self-regulation

- Use the key recommendations for implementing the PETTLEP model to help your novice shooter learn a technical skill.
- Identify a basic technique in your shooting discipline and assist your shooter to form a multisensorial mental representation using an internal perspective.
- Use imagery from an external perspective to help your shooter correct technical errors or refine shooting performance.

- Use the key recommendations for implementing the PETTLEP model to help your expert shooter improve a technical skill:

PETTLEP COMPONENT	ACTIVITIES IN THE FIELD
Physical	
Environmental	
Task	
Timing	
Learning	
Emotion	
Perspective	

- Identify the core components of the action of your shooter and examine their effectiveness during training.
- Use the five-step strategy routine to help your shooter improve a technical skill. Incorporate the core components of the action in the five-step strategy:

STEP	ACTIVITIES IN THE FIELD
Readying	
Imaging	
Focusing	
Executing	
Evaluating	

Power Point Presentation

Slides 44 to 71.

CHAPTER 4 – BREATHING AND MUSCLE TENSION/RELAXATION FOR AROUSAL SELF-REGULATION

OVERVIEW

Arousal is defined as a combination of physiological and psychological activation of the organism, which varies on a continuum from deep sleep to intense excitement. Too high or too low levels of arousal are associated with poor performance, whereas best performance is obtained in an optimal state of psychophysical activation. Debilitative anxiety, feelings of nervousness, worry, and apprehension, and other dysfunctional emotional states are often accompanied by increased activation. Performing well in fine motor skills like shooting requires relatively low levels of arousal. However, when the level is too low, the performer may feel lethargic, debilitated, and unmotivated. Thus, athletes need to regulate themselves to reach an optimal level of activation. The main self-regulation techniques to increase arousal (psyching up) or decrease arousal (psyching down) include breathing and muscle tension/relaxation. These can be taught to athletes to help them achieve the best conditions to perform in training and competition.

INTRODUCTION

Arousal involves activation of the reticular activating system in the brainstem, the autonomic nervous system, and the endocrine system. Activation leads to increased heart rate, respiration rate, blood pressure, muscle tension, and other autonomic nervous system reactions. This is a condition of sensory alertness, mobility, and readiness to respond that athletes experience through bodily signals, such as pounding heart, sweaty palms, tight muscles, or laboured breathing.

A well-known proposition on how arousal influences performance is the Yerkes-Dodson law, which predicts an inverted U-shaped relationship between arousal and performance. As shown in Figure 4.1, performance tends to increase as arousal increases from a low level (such as feeling drowsy or sluggish) to a moderate level, but only to a certain extent. As arousal continues to increase from feeling alert to being very excited or agitated, performance decreases again.

The optimal level of arousal depends largely on the person and the task performed. Some people perform better with low arousal, especially very anxious ones, some with a medium amount, and others with a higher level of arousal. The nature of the task also influences the optimal arousal level. High levels of excitement usually facilitate performance in power, strength, speed, and endurance tasks, such as sprinting and weightlifting, while a low level of excitement is not conducive to optimal performance in these tasks. For fine motor skills, such as shooting and archery, high arousal is usually detrimental to performance while relatively low arousal level is facilitating. The optimal arousal for sports like tennis, gymnastics, and volleyball falls somewhere between these extremes.

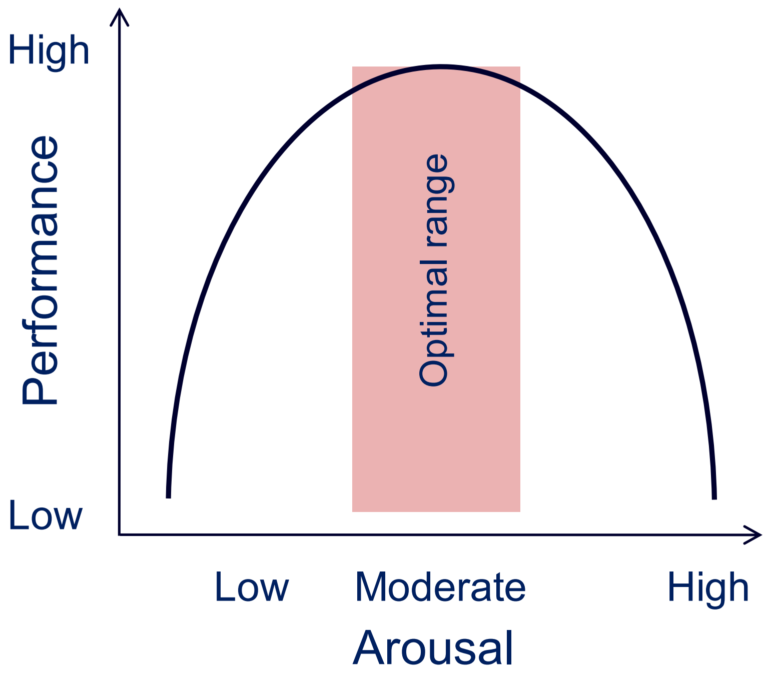

Figure 4.1. The inverted-U relationship between arousal and performance.

The effects of arousal on performance can be explained using the so-called cue-utilization hypothesis. In any performance context there are many relevant and irrelevant stimuli in the environment that can attract attention. Under optimal arousal conditions, a person can selectively attend to relevant stimuli while blocking or ignoring irrelevant ones. However, in conditions of low arousal the field of attention broadens and thus include both relevant and irrelevant stimuli. For example, a shooter in a low arousal situation while competing against a lower skilled opponent could start paying attention to irrelevant stimuli in the environment (e.g., friends in the stands or other shooters). As a result, attention may not be directed to all the relevant cues for shooting. On the contrary, in high arousal conditions, the attention in narrowed excessively thus causing the exclusion of some relevant stimuli. For example, a highly aroused rifle shooter may miss important information from wind flags that warn of changes in wind direction. Furthermore, the increase in heart rate and muscle tension associated with high arousal tends to compromise the control and accuracy of fine movements.

Given that athletes need to attain an optimal arousal level to perform at their best, several self-regulation techniques have been identified to psych up (increase arousal) or psych down (decrease arousal). The most popular techniques involve breathing and muscle tension/relaxation. Frequent and shallow thoracic breathing, associated with muscle tension and/or rapid movements such as warm-up exercises and hops, increases heart rate and arousal level. On the other hand, deep and slow diaphragmatic breathing, combined with muscle relaxation and/or slow movements, reduces heart rate and arousal. However, being able to quickly and effectively regulate the own arousal level requires learning and systematic application of breathing and muscle tension/relaxation techniques during training and competition.

BREATHING

Breathing is essential to survival. Breathing is necessary for energy production, which takes place in the cells of body, and also for modulating abdominal pressure, which is important for movement and stability of the body. People take about 20,000 breaths a day. Therefore, improving breathing brings noticeable benefits to every aspect of daily life. It makes life more comfortable, people more alert and energetic, and improves exercise and sport performance.

There are basically two ways of breathing. One way is to breathe using the chest muscles, the other way is to breathe using the diaphragm, the thin muscle that separates the lungs from the abdominal cavity. With thoracic breathing, the chest and ribs expand with each inhalation, while the abdomen remains relatively still. With diaphragmatic breathing, the stomach expands as the diaphragm moves downward to allow air to fill the lungs. People routinely use a combination of thoracic and diaphragmatic breathing. Rapid, shallow, and thoracic breathing stimulates the sympathetic branch of the autonomic nervous system. It is this system that is activated when a person becomes anxious. Its activation produces many of the unpleasant bodily sensations experienced during anxiety. Slow, deep, diaphragmatic breathing, on the other hand, stimulates the parasympathetic branch of the autonomic nervous system. It is this system that is activated when a person relaxes. Its activation produces the comfortable bodily sensations experienced during states of deep relaxation.

Rapid and shallow breathing is associated with high arousal. Therefore, one way to increase the arousal level is to intentionally take short, frequent breaths. This type of breathing should not be prolonged because this could lead to too high arousal. Hyperventilation can also lead to hypocapnia, a reduced concentration of carbon dioxide dissolved in the blood (respiratory alkalosis) and related symptoms of dizziness. On the other hand, slow and deep breathing reduces the level of arousal and facilitates relaxation. Breathing properly is relaxing and facilitates performance by increasing the amount of oxygen in the blood and bringing more energy to the muscles. Learning to take a deep, slow, and complete breath starting from the belly and involving the whole rib cage tends to trigger a relaxation response.

There are many breathing techniques adapted to western culture that originate from oriental meditation practices. For example, yoga breathing (Pranayama) basically consists of deliberate and conscious control of the breathing process in four distinct phases:

1) continuous and uniform inhalation through the nostrils expanding the rib cage and belly by lowering the diaphragm;
2) a pause in breathing by holding air in the lungs;
3) regular and continuous exhalation letting air flow from the lungs through the mouth by contracting the rib cage and abdominal muscles;
4) a breathing pause with empty lungs. In this last phase there is an effortless suspension of breathing, at the end of which the cycle begins again through a slow and regular flow of air through the nostrils.

Proper breathing comes from the diaphragm. With a full breath, the diaphragm lowers causing the belly to expand and determining a vacuum in the lungs. This results in an airflow that fills the lungs from below. To enhance awareness of diaphragmatic breathing, the individual can place one hand on the abdomen and the other on the upper chest. When taking a deep and complete breath starting from the diaphragm, the hand on the abdomen will move out with the inhalation and in with the exhalation, while the hand on the chest will remains relatively still. The time ratio between inhalation and exhalation usually suggested is 1 to 2 (1: 2). Athletes can be asked to take a deep and complete breath by counting of 4 during inhalation and 8 during exhalation. If athletes run out of breath before reaching 8, they can be advised to take a deeper breath and exhale more slowly. With practice and deep relaxation, the athlete may need to change the count to 5:10 or 6:12. This exercise creates a very powerful relaxation response when done correctly.

To develop awareness of the dynamics of exhalation, athletes can be asked to forcefully empty all the air from their lungs and note what happens on the next inhalation. When taking a full breath, athletes can imagine that their lungs are divided into three levels and that inhalation occurs in three stages:

1) air fills the lower part of the lungs as the diaphragm lowers and gently inflates the belly that remains relaxed;
2) air fills the central part of the lungs as the thoracic cavity expands and lifts the rib cage;
3) the air reaches the top of the lungs by raising the collarbones and widening the shoulder blades.

All three stages of inhalation proceed continuously and regularly. When athletes feel comfortable with this sequential breathing they should focus on a long, slow, and deep inhalation through the nose, inhaling as much air as possible. During exhalation, the emphasis is on feeling that the lungs gradually and completely empty. The upper part of the lungs is emptied first, then the middle area of the rib cage, and finally the lower part of the lungs. The exhalation should be long, slow, and complete and result in total relaxation when the air is exhaled completely. It is important that athletes focus on the feelings of calmness, relaxation, and well-being immediately after exhaling completely. Whenever athletes feel excessively tense or agitated, they should try to recreate this moment of calm by practicing this exercise.

Another relaxing technique that can be used before or during training and competition is the "5-to-1 count". The athlete is asked to mentally repeat and visualize the number 5 while taking a deep and slow breath and then exhaling completely using the diaphragm. The numbers 4 to 1 are then visualized and mentally repeated each within the breathing cycle, feeling that relaxation deepens with each number. Whenever athletes notice tension or anxiety or early cues associated with uncomfortable feelings, they should shift to slow, deep, diaphragmatic breathing and pay attention to the feelings in the abdomen as it expands and falls.

Focusing and re-focusing attention on the breathing rhythm and diaphragm is also useful when the athlete is not concentrated, or attention fluctuates due to distracting stimuli or intrusive thoughts. This can be accomplished through “centering”. The athlete slowly inhales through the nose, fills the stomach (not the chest) with air and, while doing this, thinks of a point behind the navel and says “centre”. The athlete then slowly exhales through the mouth, consciously relaxes the muscles and, while exhaling, says “relax” and lets the body do just that.

MUSCLE TENSION/RELAXATION

Most of the tension/relaxation techniques derive from the well-known Jacobson’s progressive relaxation. Jacobson’s procedure requires people to lie on their back in a reclining chair, on a mat on the floor, or on the bed, in a quiet room, without interruptions, with arms and legs not crossed to avoid unnecessary stimulation. Progressive muscular relaxation consists of a series of exercises that include:

1) systematic tension of specific muscle groups in a predetermined order;
2) maintaining contraction for 5-7 seconds;
3) relaxation.

Tension/relaxation often starts from the head and moves down through the body to the feet or vice versa. The contraction phase develops awareness on the sensations associated with muscle tension, while the relaxation phase develops awareness on the related sensations and how muscle relaxation can be induced voluntarily by releasing tension. Therefore, initially the athlete simply identifies a localized state of tension, relaxes it, and compares the sensations of tension with the relaxation that derives from the elimination of tension. As practice progresses, relaxation of a muscle group triggers relaxation of the next muscle group in the sequence. Through practice, the athlete can gain experience in recognizing unwanted feelings of tension wherever they occur and can therefore easily release tension quickly in any stressful situation.

The initial practice takes 25-30 minutes and should be done daily. The coach or sport psychologist should guide the athletes during the initial sessions, then provide them with guidelines or an audio track containing instructions for the tension/relaxation sequence of the muscle groups (see Appendix A for a progressive muscular relaxation script and instructions for using it). A well-developed relaxation training programme requires a lot of practice in the beginning, but afterwards complete relaxation can be achieved in a few minutes. Once able to consistently achieve a desirable state of relaxation, athletes can use a shorter procedure to achieve deep muscle relaxation by combining some of the muscle groups: hands, biceps, and forearms; face and neck; shoulders, abdominals, and buttocks; legs and feet.

After learning how to actively relax the muscles, the athlete can switch to passive relaxation without first tensing the muscles. Many people find this passive form of relaxation more effective and pleasant than the active form. Through passive relaxation, the athlete simply directs attention to the muscles, gradually relaxes every part of the body deeper and deeper, and releases tension. The same complete or abbreviated sequence of body parts considered in active progressive relaxation can be used for passive progressive relaxation (see Appendix 2).

The momentary muscle relaxation exercises, lasting a few seconds, are also useful before or during performance, such as just before shooting or between shots. Through a rapid scan of the body from head to toes (or from feet to head), attention can be focused only on muscle groups where the level of tension is too high. After releasing the tension, the scan continues to other parts of the body. Scanning the neck and shoulders is also important because it is very common to have excessive tension in these areas when worried or anxious.

Therefore, periodic scanning of these muscles allows to release tension through active or passive relaxation. Releasing excessive tension in these two areas tends to spread relaxation to the rest of the body and can have a calming effect. Finally, scanning the specific muscles involved in sport performance is also important to prepare the musculature for skill execution.

THE RELAXATION RESPONSE

The relaxation response is a technique developed by Herbert Benson inspired by oriental transcendental meditation, but without reference to mysticism and unusual postures. It is an effective way to relax away from competition and can be transferred to pre-competition contexts once learned. This technique combines breathing and muscle relaxation. The relaxation response requires two essential components: a mental device and a passive attitude. For a mental device, athletes can use a word like calm, relax, smooth, easy, float, or a word/sound of their choice. Benson proposed the following instructions for inducing the relaxation response:

1) Pick a focus word, sound, or phrase, that has significant meaning for you and that you associate with relaxation.
2) Sit in a comfortable position in a quiet place.
3) Close your eyes.
4) Deeply relax your muscles, progressing from your feet to your calves, thighs, abdomen, shoulders, neck, and head (or head to feet if preferred) and keep them relaxed.
5) Concentrate on breathing easily and naturally through the nose. With each breath out, say the focus word, sound, or phrase silently to yourself as you exhale.
6) Assume a passive attitude. When other thoughts come to mind, simply return to your word/sound repetition.
7) Continue for 10 to 20 minutes.

8) Do not stand immediately. Continue sitting quietly for a minute or so, allowing other thoughts to return. Then open your eyes and sit for another minute before rising.
9) Practice the technique once or twice daily. Good times to do so are before breakfast and before dinner.

Being able to relax through the relaxation response technique and all the other methods described above is useful not only for performance in precision sports, but also to deal with the physical symptoms of stress, accelerate post-performance recovery, facilitate sleep, and improve health and wellbeing.

SUMMARY

As a mixture of physiological and psychological activation, arousal varies along a continuum from deep sleep to intense excitement. An optimal range of arousal level is associated with good performance. The optimal arousal level for performing precision motor skills such as shooting is relatively low. Debilitative anxiety and other emotional states tend to increase activation. Therefore, shooters must learn to self-regulate. The main self-regulation techniques include breathing and muscle tension/relaxation. These techniques can be taught to athletes to help them self-regulate quickly and effectively and achieve their best performance conditions in training and competition.

Athletes must first become aware of how different types of breathing—thoracic or diaphragmatic, rapid or slow, shallow or deep—influence their activation and performance. Different techniques can be used to this purpose, such as:

1) paying attention to the breathing modality (thoracic and diaphragmatic) and rhythm;
2) changing breathing modality and rhythm;
3) controlling the four phases of the breathing process (i.e., inhalation, pause with full

lungs, exhalation, pause with empty lungs);

4) changing the time ratio between inhalation and exhalation, using sequential breathing (i.e., air filling the lower, central, and upper parts of the lungs);
5) using the 5-to-1 count;
6) shifting to slow, deep, diaphragmatic breathing while under stress;
7) focusing on the breathing rhythm and diaphragm ("centering").

Breathing can be combined with muscle/tension relaxation techniques. These include:

1) active progressive relaxation (i.e., systematic tension and relaxation of muscle groups);
2) passive progressive relaxation;
3) momentary muscle relaxation (body scan);
4) neck and shoulder scan;
5) specific muscle scan;
6) relaxation response.

Similarly to teaching motor skills, self-regulation techniques should be individualized to meet the specific needs of the athlete. Once learned and applied in training, these techniques can be easily, quickly, and effectively applied in competition.

Suggested Readings

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Self-Evaluating Questions

- How can arousal be defined?
- What is the difference between "psyching up" and "psyching down" techniques?
- Describe the relationship between arousal and performance.
- Why do too high or too low arousal levels tend to hamper performance?
- Discuss the two basic breathing modalities and their effects on performance.
- How would you use breathing to decrease athletes' arousal level?
- Describe the main breathing techniques to regulate arousal.
- What are the main muscle tension/relaxation techniques for arousal regulation?
- Describe the relaxation response technique.

Practical Activities in the Field to apply breathing and muscle tension/relaxation techniques for arousal self-regulation

- Discuss arousal self-regulation procedures with one of your athletes.

- Using the following list of body parts, write a progressive relaxation script to be applied with one of your athletes:

BODY AREAS	INSTRUCTIONS FOR MUSCLE RELAXATION AND BREATHING
1. Right hand and lower arm	
2. Right biceps	
3. Left hand and lower arm	
4. Left biceps	
5. Head	
6. Neck and shoulders	
7. Abdomen and buttocks	
8. Right thigh	
9. Right foot, ankle, and calf	
10. Left thigh	
11. Left foot, ankle, and calf	

- Based on the above progressive relaxation script, identify a short relaxation procedure with your athlete, involving no more than three body areas, to be applied immediately before performance and between shoots:

BODY AREAS	"PSYCHING DOWN" INSTRUCTIONS
1.	
2.	
3.	

- Repeat the same procedure this time with the aim of increasing (rather than decreasing) the level of arousal:

BODY AREAS	"PSYCHING UP" INSTRUCTIONS
1.	
2.	
3.	

Power Point Presentation

- Slides 72 to 81.

APPENDIX 1. PROGRESSIVE MUSCULAR RELAXATION

The following is a progressive muscular relaxation script. You can read the script, record it, and play it back, or you can familiarize yourself with the instructions and do the exercises yourself. Initially, you can relax in a quiet place and in a comfortable position. Afterwards, you can relax in different places, for example on the bus while traveling or while sitting on a bench before competing. You can relax when you need it, for example the night before a competition or the morning of an event.

You will be asked to tense different muscle groups for about 5 seconds and then relax the muscles for 20 seconds. Start tensing when asked to tense. Hold the tension until you are told to relax. As soon as you hear the word relax, release all tension in that muscle and focus attention upon the muscle as it relaxes.

Lie down in a comfortable position and close your eyes. You will start by tensing your leg muscles. Then you will move to the trunk, arms, shoulders, neck and face.

- Tense the muscles in your right calf. Feel the tension in your right calf. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. Feel relaxation in your right calf. *Relax for 20 seconds*.

- Tense the muscles in your right thigh. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. Your right leg is feeling nice and relaxed. *Relax for 20 seconds*.

- Now move on to your left leg. Tense the muscles in your left calf. Feel the tension in your left calf. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

- Now tense the muscles in your left thigh. *Keep tension for 5 seconds*.
- Relax and breathe slowly and deeply. Both of your legs feel nice and relaxed. *Relax for 20 seconds*.
- You will now start work on your trunk and upper body.
- Now tense your abdominal muscles. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. That feeling of relaxation is spreading up your body. *Relax for 20 seconds*.

- Now tense your pectoral muscles. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. Feel the relaxation spread up your body. *Relax for 20 seconds*.

- Now tense your shoulders by pushing against the surface you are lying on. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. Your legs and upper body are relaxed. *Relax for 20 seconds*.
You will now work on relaxing your arms, starting with your right arm.

- Tense the muscles in your right forearms. Feel the tension in your forearm. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

- Now tense the muscles in your right biceps. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. Your entire right arm is feeling nice and relaxed. *Relax for 20 seconds*.
You will now move to your right arm.

- Tense the muscles in your left forearm. Feel the tension in your left forearm. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

- Now tense the muscles in your left biceps. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. Notice how both of your arms, along with your legs, trunk, and shoulders, are feeling nice and relaxed. *Relax for 20 seconds*.

- Now tense your neck muscles by pushing your head gently against the surface you are lying on. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

You will now finish by relaxing your facial muscles.

- Tense your jaw muscles by pulling an exaggerated smile. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

- Now tense your cheek muscles by pushing your lips out and squinting your eyes. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

- Tense your forehead muscles by raising your eyebrows as high as you can. *Keep tension for 5 seconds*.

Relax and breathe slowly and deeply. *Relax for 20 seconds*.

Notice how relaxed your whole body feels. Enjoy this feeling of relaxation.

Scan your body to see if you have any remaining tension.

Start with your left calf, then your left thigh, followed by your right calf and right thigh. If there is any tension, tense the muscle and then let it relax.

Now scan your abdominals, followed by your chest, then shoulders. Again, if there is any tension, systematically tense and then relax the muscles.

Now scan your right forearm, right biceps, left forearm, left biceps, neck muscles, jaw muscles, cheek muscles, and forehead. You can now enjoy this complete state of relaxation.

Relax for 1 minute.

Notice how your muscles and your whole body feel refuelled. Enjoy the feeling of your muscles being completely relaxed. You may feel a warm sensation throughout your body, or you may even feel as though you have sunk into the floor or into the chair that you are sitting on. Alternatively, you may feel very light, almost as though you could float away.

Whatever you are feeling, enjoy being relaxed.

Before opening your eyes, take some deep breaths and allow energy and the feeling of alertness to flow through your body.

Inhale deeply to the count of four (1 . . . 2 . . . 3 . . . 4). Now exhale to the count of six (1 . . . 2 . . . 3 . . . 4 . . . 5 . . . 6). Inhale deeply to the count of four (1 . . . 2 . . . 3 . . . 4). Now exhale to the count of six (1 . . . 2 . . . 3 . . . 4 . . . 5 . . . 6). Inhale deeply to the count of four (1 . . . 2 . . . 3 . . . 4). Now exhale to the count of six (1 . . . 2 . . . 3 . . . 4 . . . 5 . . . 6). Inhale deeply to the count of four (1 . . . 2 . . . 3 . . . 4). Now exhale to the count of six (1 . . . 2 . . . 3 . . . 4 . . . 5 . . . 6).

Stretch your arms and then stretch your legs.

Now open your eyes.

APPENDIX 2. PASSIVE MUSCULAR RELAXATION

After becoming proficient in active and deep muscle relaxation, you can engage in passive muscle relaxation. With passive muscle relaxation you do not have to tense your muscles before relaxing them. You just have to let go of any tension in the muscles. As with active relaxation, put yourself in a comfortable position, then bring attention to each muscle group and let the tension flow away. Relax your muscle groups in the following order:

1. Right hand and lower arm
2. Right biceps
3. Left hand and lower arm
4. Left biceps
5. Muscles in face—forehead, eyes, and mouth
6. Neck and shoulders
7. Abdomen and buttocks
8. Right thigh
9. Right foot, ankle, and calf
10. Left thigh
11. Left foot, ankle, and calf