International Shooting Sport Federation (ISSF)

ISSF Coach (second level)

SPORT SCIENCE
Sport Science
ISSF Coach (second level)

Contents

Chapter 1 – Motor skill learning
Chapter 2 – Scheduling practice for learning
Chapter 3 – Improving performance through mental practice
Chapter 4 – Breathing and muscle tension/relaxation for arousal self-regulation
Contents

Chapter 1 – Motor skill learning

- Motor skills
- Classification of motor skills
- Stages of learning
- Instructional priorities in the stages of learning
<table>
<thead>
<tr>
<th>Terms</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movements</td>
<td>Specific patterns of motion among joints and body segments to accomplish action goals.</td>
</tr>
<tr>
<td>Motor abilities</td>
<td>Genetically determined potentialities of action that underlie the execution of movements and skilled performance.</td>
</tr>
<tr>
<td>Motor skills</td>
<td>Goal-directed activities to achieve results with maximum certainty, minimum expenditure of time, energy or both. They are learned and improved by practice.</td>
</tr>
<tr>
<td>Motor learning</td>
<td>A set of internal processes associated with practice or experience leading to relatively permanent gains in the capability for skilled performance.</td>
</tr>
<tr>
<td>Motor control</td>
<td>The way the neuromuscular system works to activate and coordinate muscles and limbs.</td>
</tr>
<tr>
<td>Skilled performance</td>
<td>Learned proficiency to achieve a desired outcome on a given task with maximum certainty (i.e., effectiveness) and efficiency.</td>
</tr>
</tbody>
</table>
## Abilities vs. Skills

<table>
<thead>
<tr>
<th>Abilities</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inherited traits</td>
<td>• Developed with practice</td>
</tr>
<tr>
<td>• Stable and enduring</td>
<td>• Modified with practice</td>
</tr>
<tr>
<td>• Few in number</td>
<td>• Many in number</td>
</tr>
<tr>
<td>• Underlie the performance of many different skills</td>
<td>• Depend on different subset of abilities</td>
</tr>
</tbody>
</table>
Abilities

• Reaction time
• Finger & manual dexterity
• Speed of movement
• Strength
• Explosive strength
• Gross body coordination
• Stamina (cardiovascular endurance)
• Flexibility
• …
Skill
developed as a result of practice

The capacity of producing a performance result with:

1) maximum certainty (effectiveness)
2) minimum energy (efficiency) or minimum time

Three main components:

1) **cognitive** - deciding *what to do* to achieve the performance goal;
2) **perceptual** - deciding *where and when to do* the action in function of relevant environmental features;
3) **movement** - deciding *how to do* the action
Performance

Movement Efficiency
- Energy consumption
- Oxygen consumption
- Cardiac activity
- Electromyographic activity
- Cortical activity
- ...

Movement Efficacy
- Accuracy
- Coordination
- Force production
- Movement speed
- Outcome, Result
- ....
Classification of motor skills
(1/3)

Gross skills

Intermediate skills

Steering a car
Pitching a golf ball
Shotgun shooting

Fine skills

Walking
Hopping
Jumping

Handwriting
Buttoning a shirt
Triggering in shooting
Classification of motor skills
(2/3)

Discrete skills
- Tennis serve
- Hitting a baseball
- Shooting

Serial skills
- Playing piano
- Triple jump
- Gymnastics routine

Continuous skills
- Steering a car
- Running
- Swimming
Classification of motor skills

(3/3)

Closed skills
- Dart throwing
- Bowling
- Shooting

Intermediate skills
- Windsurfing
- Kayaking
- Skiing

Open skills
- Driving a car in traffic
- Playing rugby
- Wrestling
Stages of learning

Fitts and Posner model

Cognitive stage  Associative stage  Autonomous stage

Novice level  Advanced level  Expert level

Dynamic systems model
Fitts and Posner stages of learning

Cognitive stage (beginner) (1/2)

- Many errors
- Great variability in errors
- Irregular movement patterns
- Blocked joints, rigidity, and movement limited
- Stiff muscles in complex movements
- Slow response time
Fitts and Posner stages of learning

**Cognitive stage (beginner) (2/2)**

- 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
Fitts and Posner stages of learning

<table>
<thead>
<tr>
<th>Associative stage (intermediate)</th>
<th>1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Decreased frequency of errors</td>
<td></td>
</tr>
<tr>
<td>• Less pronounced errors</td>
<td></td>
</tr>
<tr>
<td>• Understanding of basic skill requirements</td>
<td></td>
</tr>
<tr>
<td>• Faster, smoother, and more effective movements</td>
<td></td>
</tr>
<tr>
<td>• Joints released; wider and more flexible movements as synergies develop</td>
<td></td>
</tr>
</tbody>
</table>
Fitts and Posner stages of learning

**Associative stage (intermediate) (2/2)**

- Automatic execution of some movement segments and conscious control of other parts
- Greater movement adaptability to environmental changes
- Less cognitive activity required
- Higher performance
Fitts and Posner stages of learning

Autonomous stage (advanced) (1/2)

- 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 cues while executing
Fitts and Posner stages of learning

Autonomous stage (advanced) (2/2)

- 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 (effort) required
- Movement largely controlled automatically
- High performance
Instructional priorities in the stages of learning

Cognitive stage

- Use verbal instructions and demonstrations
- Involve learners in goal-setting
- Provide short information
- Help learners identify appropriate sources of information
- Highlight how acquired skills and knowledge can be transferred
- Provide relatively frequent feedback regarding main errors
- Reinforce individual’s performance improvements, participation, and efforts
- Simplify techniques if necessary
Instructional priorities in the stages of learning

**Associative stage**

- Stimulate learners to identify and respond to changes in environmental conditions
- Increase movement variability
- Gradually withdraw the amount of feedback
- Encourage learners to assess themselves
- Reinforce correct movement behaviours
- Instruct learners to focus on the appropriate cues
- Continue to reinforce improvements, participation, and efforts
Instructional priorities in the stages of learning

Autonomous stage

- Maintain learners’ motivation levels high
- Emphasise improvements through involvement and dedication
- Focus instructions on refining and adapting movements
- Help learners to refine and adapt their well-learned skills to a range of environmental conditions
- Encourage self-analysis and personal solutions to difficulties
Dynamic systems model

Organism

Perception

Task

Environment

Action

Performance
Instructional priorities in the stages of learning

Novice stage

- 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
Instructional priorities in the stages of learning

**Advanced stage**

- 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)
Instructional priorities in the stages of learning

**Expert stage**

- 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
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Chapter 1 – Motor skill learning

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Chapter 2 – Scheduling practice for learning

- Massed and distributed practice
- Constant and variable practice
- Blocked and random/serial practice
- Practice variability and contextual interference
- Whole and part practice
Learning phases
Fitts & Posner – Dynamic Systems

Cognitive – Novice

Associative – Advanced

Autonomous – Expert

Performance level

Time
# DISTRIBUTION OF PRACTICE: MASSED VS DISTRIBUTED

<table>
<thead>
<tr>
<th>Distribution of practice</th>
<th>How the frequency and amount of rest are scheduled between practice sessions and within the session.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Massed practice</strong></td>
<td>A practice schedule in which the amount of rest between practice sessions or trials is relatively short.</td>
</tr>
<tr>
<td><strong>Distributed</strong></td>
<td>A practice schedule in which the amount of rest between</td>
</tr>
</tbody>
</table>
Massed and distributed practice

Between sessions
- Close sessions
  - Massed practice
    - Short rest between trials
- Spaced sessions
  - Distributed practice
    - Long rest between trials

Within a session
## PRACTICE VARIABILITY: CONSTANT VS VARIABLE

<table>
<thead>
<tr>
<th>Practice variability</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Practice variability</strong></td>
<td>The variety of movement and context characteristics that a person experiences while practicing a skill.</td>
</tr>
<tr>
<td><strong>Constant practice</strong></td>
<td>A same skill is repeated in the same way, without variations, in a fixed context in a series of trials.</td>
</tr>
<tr>
<td><strong>Varied practice</strong></td>
<td>A same skill is repeated in a variety of different ways and contexts.</td>
</tr>
</tbody>
</table>
Constant and variable practice

Constant practice

Skill performed in:
• same ways
• same conditions

Variable practice

Skill performed in:
• different ways
• different conditions

The constant/variable practice continuum
Hypothetical Comparison of Performance Curves for a Skill Acquired under Either a Constant or a Varied Practice Schedule (from Edwards, 2011)
<table>
<thead>
<tr>
<th><strong>Contextual interference</strong></th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blocked practice</strong></td>
<td>A single motor skill is practiced completely before moving to the next motor skill and so forth.</td>
</tr>
<tr>
<td><strong>Random or serial practice</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Contextual interference effect</strong></td>
<td>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 blocked manner.</td>
</tr>
</tbody>
</table>
Blocked and random/serial practice

Blocked practice
Different skills performed in blocks
Low contextual interference

Random/serial practice
Different skills performed in random or serial order
High contextual interference

The constant/variable practice continuum

Results from the experiment by Goode and Magill showing the effects of blocked and random structured practice for three types of badminton serves on acquisition, one-day retention, and transfer.

3 days a week, 3 weeks, 3 blocks of 12 trials

The day after Left side of the court

(short, long, and drive)
Random/serial practice - contextual interference -

- elaboration hypothesis
- action plan reconstruction hypothesis

Greater attention
Cognitive effort
Combining practice variability and contextual interference.

- **Random/serial practice**
  - Random/serial Constant practice
    - Low variability
    - Low interference
  - Random/serial Variable practice
    - High variability
    - High interference

- **Blocked practice**
  - Blocked Constant practice
    - Low variability
    - Low interference
  - Blocked Variable practice
    - High variability
    - High interference

Combining practice variability and contextual interference.
Practice schedule designs varying from low to high contextual interference for three skills and three variations of each skill

<table>
<thead>
<tr>
<th>Level</th>
<th>Practice Schedule</th>
</tr>
</thead>
</table>
| LOW INTERFEERENCE | a) **Blocked–constant practice**
|                | (series of skills A, B, C)                                                       |
|                | AAAAAAAAAAAAAA BBBBBBBBBBBBBB CCCCCCCCCCCC                                       |
|                | b) **Blocked–variable practice**
|                | (series of skills A, B, C with variations 1, 2, 3)                               |
|                | A₁A₂A₃A₁A₂A₃A₁A₂A₃A₁A₂A₃ B₁B₂B₃B₁B₂B₃B₁B₂B₃B₁B₂B₃C₁C₂C₃C₁C₂C₃C₁C₂C₃C₁C₂C₃ |
|                | c) **Serial–constant practice**
|                | (series of skills A, B, C in alternating order)                                  |
|                | AAABBBCCCC AAABBBCCCC AAABBBCCCC AAABBBCCCC                                     |
| HIGH INTERFEERENCE | d) **Serial–variable practice**
|                | (series of skills A, B, C with variations in alternating order)                  |
|                | A₁A₂A₃B₁B₂B₃C₁C₂C₃ A₁A₂A₃B₁B₂B₃C₁C₂C₃ A₁A₂A₃B₁B₂B₃C₁C₂C₃ A₁A₂A₃B₁B₂B₃C₁C₂C₃ |
### Example with pistol shooting skills

<table>
<thead>
<tr>
<th>Blocked-constant practice</th>
<th>Blocked-variable practice</th>
<th>Serial-constant practice</th>
<th>Serial-variable practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>The simplest condition</td>
<td>Intermediate difficulty</td>
<td>Intermediate difficulty</td>
<td>The most challenging</td>
</tr>
<tr>
<td><strong>Lifting:</strong></td>
<td><strong>Sighting:</strong></td>
<td><strong>Triggering:</strong></td>
<td></td>
</tr>
<tr>
<td>1) 15 rep, no var</td>
<td>1) 5 rep, var 1</td>
<td>1) 5 rep, no var</td>
<td>1) 5 rep, var 1</td>
</tr>
<tr>
<td>2) 15 rep, no var</td>
<td>2) 5 rep, var 2</td>
<td></td>
<td>2) 5 rep, var 2</td>
</tr>
<tr>
<td>3) 15 rep, no var</td>
<td>3) 5 rep, var 3</td>
<td></td>
<td>3) 5 rep, var 3</td>
</tr>
</tbody>
</table>

**Total:** 45 rep
| **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. |
Whole and part practice

Task complexity

Whole practice

Combination of whole and part practice

Task organisation

Part practice

Low

High

High

Low
Whole and part practice

- whole-part-whole practice
- segmentation
- progressive part practice
- attentional cueing
- simplification
Sport Science
ISSF Coach (second level)

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Chapter 3 – Improving performance through mental practice

- The PETTLEP model
- Performance routines
- The five-step strategy
- Identifying the core components of the action
Results of the experiment by McBride and Rothstein (1979) showing test and one-day test retention performance following 40 trials of mental practice, physical practice, and a combination of physical and mental practice for a closed motor skill.
Results of the experiment by McBride and Rothstein (1979) showing test and one-day test retention performance following 40 trials of mental practice, physical practice, and a combination of physical and mental practice for a open motor skill.
Imagery in Sport: Where, When, Why, and What

Where?

• Athletes employ imagery more in competition than in training

When?

• Athletes use imagery before, during, and after practice; outside of practice; before, during, or after competition; and for injury rehabilitation
Imagey in Sport: Where, When, Why, and What

What?

- Aspects: Surroundings, the senses involved, the perspective (internal vs. external)

Why?

- For motivational and cognitive functions
Imagery perspective

- **Internal** perspective: rehearsing execution from the own vantage point (like having a camera on the head)

- **External** perspective: rehearsing execution from the perspective of an outside observer (like watching a movie)
How Imagery Works: Five Theories

• Psychoneuromuscular theory
• Symbolic learning theory
• Bioinformational theory
• Triple code model
  (Imagery, Somatic response, Meaning)
• Psychological perspective

Figure 1
Heart rate, 5-s sampling, of an archer under different treatment conditions.
Imagery use

- Improve concentration
- Enhance motivation
- Build confidence
- Control emotional responses
- Acquire, practice, and correct sport skills
- Acquire and practice strategy
- Prepare for competition
- Cope with pain and adversity
- Solve problems
The ‘PETTLEP’ model
Holmes & Collins (2001)
## The ‘PETTLEP’ model

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>All imagery should be performed in the way you would shoot</td>
</tr>
<tr>
<td>Environment</td>
<td>Cues of the actual environment</td>
</tr>
<tr>
<td>Task</td>
<td>Focus on meaningful aspects of shooting</td>
</tr>
<tr>
<td>Timing</td>
<td>Imagery movements in real time as much as possible</td>
</tr>
<tr>
<td>Learning</td>
<td>Imagery should progress with physical skill development</td>
</tr>
<tr>
<td>Emotion</td>
<td>Awareness of own emotional reactions</td>
</tr>
<tr>
<td>Perspective</td>
<td>Internal &amp; external</td>
</tr>
</tbody>
</table>
Singer’s (2002) five-step strategy adapted by Wilson & Richards (2011) and further modified to include the core components of the action in the third step (i.e., focusing attention).
The multi-action plan (MAP) model

Optimal performance

- Monitoring
- Effective control
- Effective focus
- High energy

Supervision
- Automated execution
- Efficient & effective focus
- Optimal energy

Suboptimal performance

- Over control
- Focus disruption
- Energy misuse

- Low control
- Lack of focus
- Low energy

Bortoli et al. (2012); Robazza et al. (2016); Vitali et al. (2019)
The multi-action plan (MAP) model

Core components of action

Fundamental movements
– e.g., “positioning,” “grip,” “aiming” in precision sports –

or action-related behaviors
– e.g., intensity, effort, timing, acceleration, rhythm of movement –

subjected to variability and accuracy fluctuations, especially under challenging situations
Four-step procedure aimed at

- identifying the core components of the full sequence of actions
- testing effects in practice and competition
Example in pistol shooting

- Stance, balance
- Lifting
- Sighting
- Triggering
- Follow-through
Example in shooting

Step 1
Athlete’s description of usual optimal sequence of a single shot from start to follow-through
Pistol shooter

Position

Hand

Visualization

Breath

Grip

Align

Aiming

Follow-through

Outcome
Example in shooting

Step 2

Identification of a small number of the most important core components (two or three) deemed fundamental in order to perform optimally

Key question

Imagine yourself performing in a mental or physical non-optimal 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 would need to control intentionally in order to execute in a consistent and accurate manner, and thus attain good performance?
Pistol shooter

Position
Hand
Visualization
Breath
Grip
Align
Aiming
Follow-through
Outcome

Position
Grip
Aiming
Outcome
Example in shooting

Step 3

**Shooting session:** self-assessment of the accuracy of core components after each shot, before seeing the outcome.

**A Borg CR scale**

- nothing at all: 0
- very, very little: 0,5
- very little: 1
- little: 2
- moderate: 3
- much: 4
- very much: 5
- very, very much: 6
- maximum possible: 10
Pistol shooter

Position → Hand → Visualization → Breath → Grip → Align → Aiming → Follow-through → Outcome

Position: .33
Grip: .61
Aiming: .70
Outcome:
Step 4

The most influential core components identified are further assessed over several practice sessions under conditions of distress and fatigue.
Type 3 performance: Shooter without effective strategy

- Control level
  - .68

- Fatigue Distress
  - -.37

- Result
  - -.39
Optimal performance

Suboptimal performance

High control

Minimal control

Over control
Energy misuse
Focus disruption

Dysfunctional-unpleasant emotions/PBSs (U-)

Type 3

Bortoli, Bertollo, Hanin, & Robazza (2012)
Type 2 performance: Shooter with effective strategy
Optimal performance

Suboptimal performance

High control

Minimal control

Type 2

Control

High energy

Effective focus

Functional-unpleasant emotions/PBSs (U+)

Bortoli, Bertollo, Hanin, & Robazza (2012)
Sport Science
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Sport Science
ISSF Coach (second level)

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Chapter 4 – Breathing and muscle tension/relaxation for arousal self-regulation

- Breathing
- Muscle tension/relaxation
- The relaxation response
Arousal

Definition: Combination of physiological and psychological activation of the organism, which varies on a continuum from deep sleep to intense excitement.
The inverted-U relationship between arousal and performance
The inverted-U relationship between arousal and performance

Relatively low arousal: fine motor skills, such as shooting and archery

Relatively high arousal: power, strength, speed, and endurance tasks, such as sprinting and weightlifting
The inverted-U relationship between arousal and performance

**Psyching down:**
Deep and slow diaphragmatic breathing, muscle relaxation and/or slow movements

**Psyching up:**
Frequent and shallow thoracic breathing, muscle tension and/or rapid movements
Breathing techniques (1/2)

Paying attention to breathing modality (thoracic and diaphragmatic) and rhythm

Changing breathing modality and rhythm

Controlling the four phases of the breathing process

Changing time ratio between inhalation and exhalation

Using sequential breathing
Using the 5-to-1 count

Shifting to slow, deep, diaphragmatic breathing while under stress

Focusing on the breathing rhythm and diaphragm

...
Tension/relaxation techniques

- Active progressive relaxation
- Passive progressive relaxation
- Body scan
- Neck and shoulder scan
- Specific muscle scan
- Relaxation response

...
Jon Kabat-Zinn’s body scan exercise for relaxation