



ISSF

**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

Sport Science

ISSF Coach (second level)

Contents

Chapter 1 – Motor skill learning

- Motor skills
- Classification of motor skills
- Stages of learning
- Instructional priorities in the stages of learning

Terms

Definitions

Movements

Specific patterns of motion among joints and body segments to accomplish action goals.

Motor abilities

Genetically determined potentialities of action that underlie the execution of movements and skilled performance

Motor skills

Goal-directed activities to achieve results with maximum certainty, minimum expenditure of time, energy or both. They are learned and improved by practice.

Motor learning

A set of internal processes associated with practice or experience leading to relatively permanent gains in the capability for skilled performance.

Motor control

The way the neuromuscular system works to activate and coordinate muscles and limbs.

Skilled performance

Learned proficiency to achieve a desired outcome on a given task with maximum certainty (i.e., effectiveness) and efficiency.

Abilities vs. Skills

Abilities

- Inherited traits
- Stable and enduring
- Few in number
- Underlie the performance of many different skills

Skills

- Developed with practice
- Modified with practice
- Many in number
- Depend on different subset of abilities

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

Walking
Hopping
Jumping

Intermediate skills

Steering a car
Pitching a golf ball
Shotgun shooting

Fine skills

Handwriting
Buttoning a shirt
Triggering in shooting

Classification of motor skills

(2/3)

Discrete skills

Continuous skills

Serial skills

Tennis serve
Hitting a baseball
Shooting

Playing piano
Triple jump
Gymnastics routine

Steering a car
Running
Swimming

Classification of motor skills

(3/3)

Closed skills

Dart throwing
Bowling
Shooting

Intermediate skills

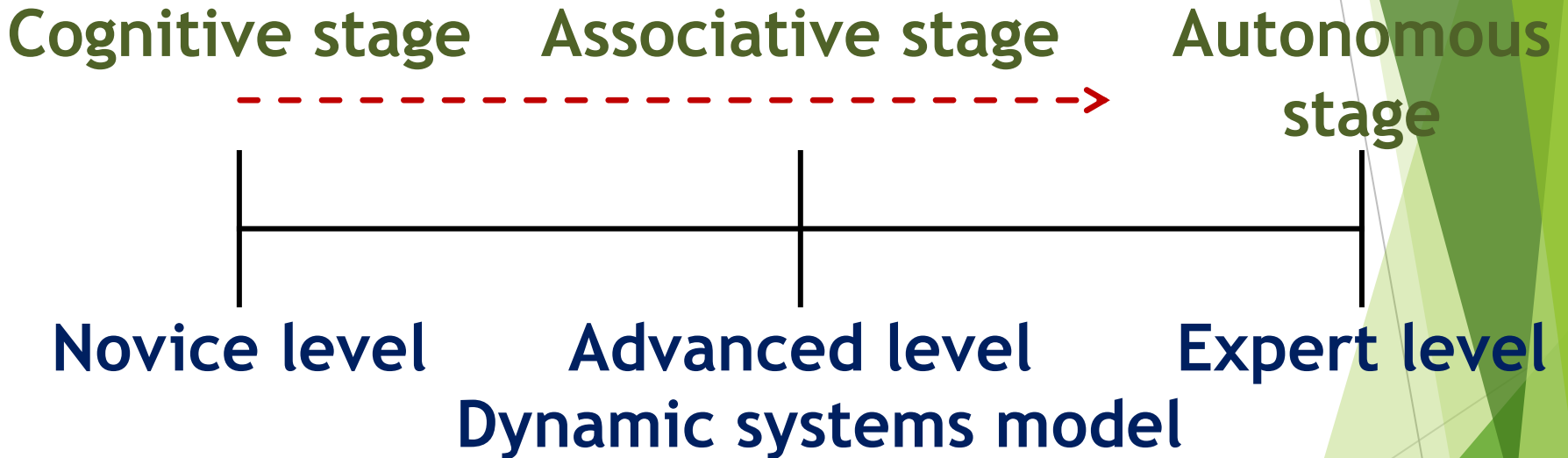
Windsurfing
Kayaking
Skiing

Open skills

Driving a car in traffic
Playing rugby
Wrestling

Stages of learning

Fitts and Posner model



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

Associative stage (intermediate) (1/2)

- 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

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

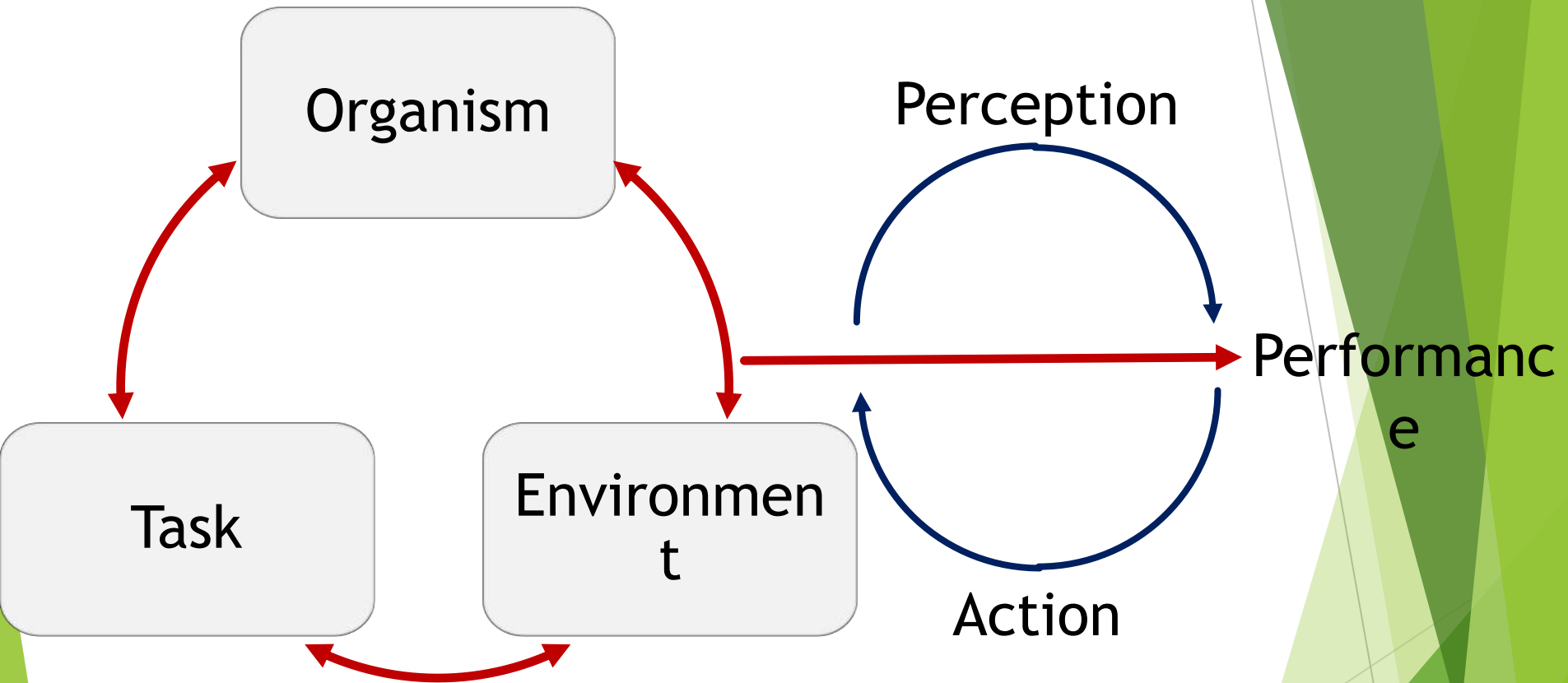
- Stimulate learners to identify and respond to changes in environmental conditions
- Increase movement variability
- Gradually withdraw the amount of feedback
- Encourage learners to assess themselves
- Reinforce correct movement behaviours
- Instruct learners to focus on the appropriate cues
- Continue 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



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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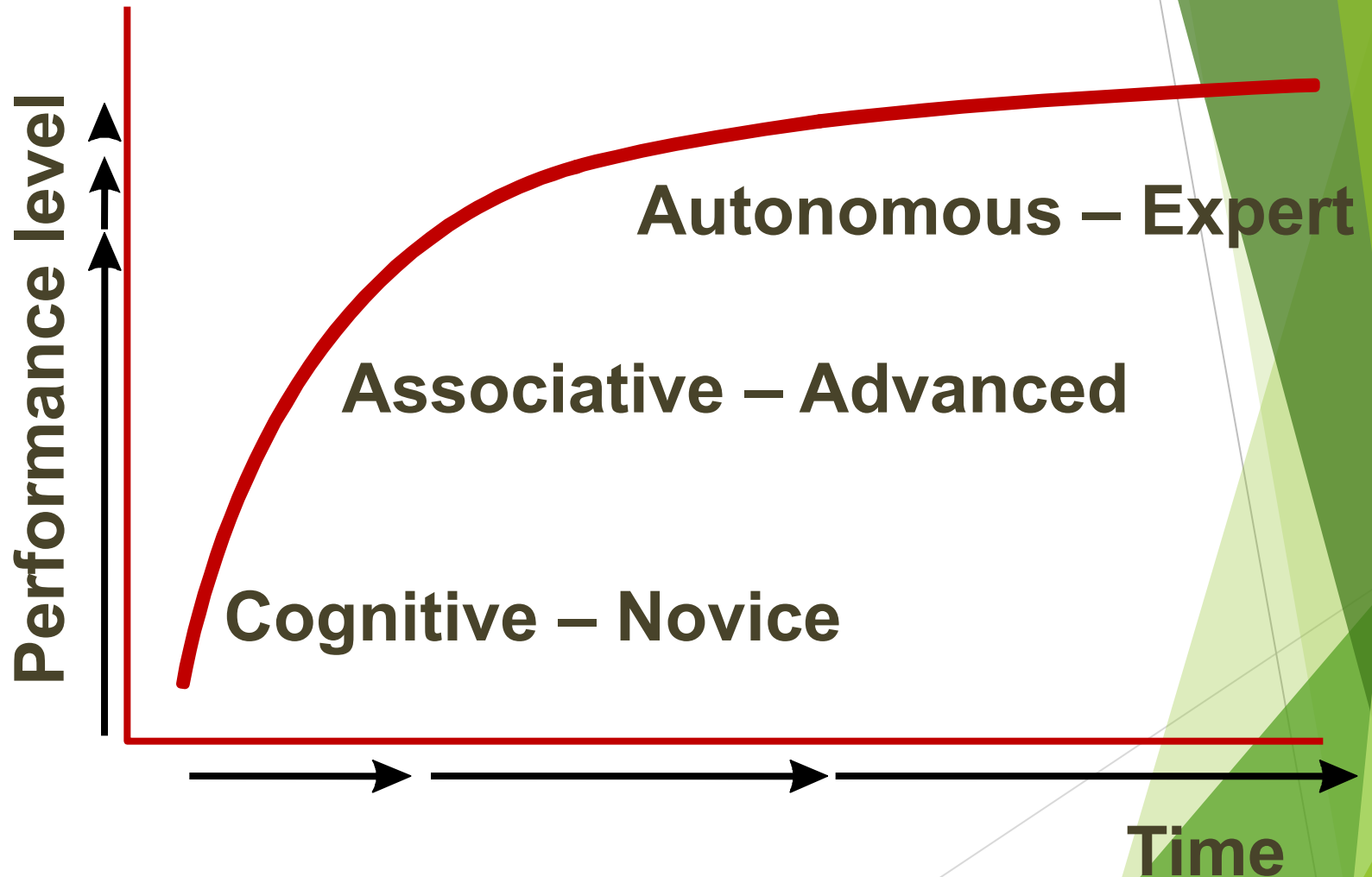
Contents

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



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

A practice schedule in which the amount of rest between

Massed and distributed practice

Between sessions

Close sessions

Spaced sessions

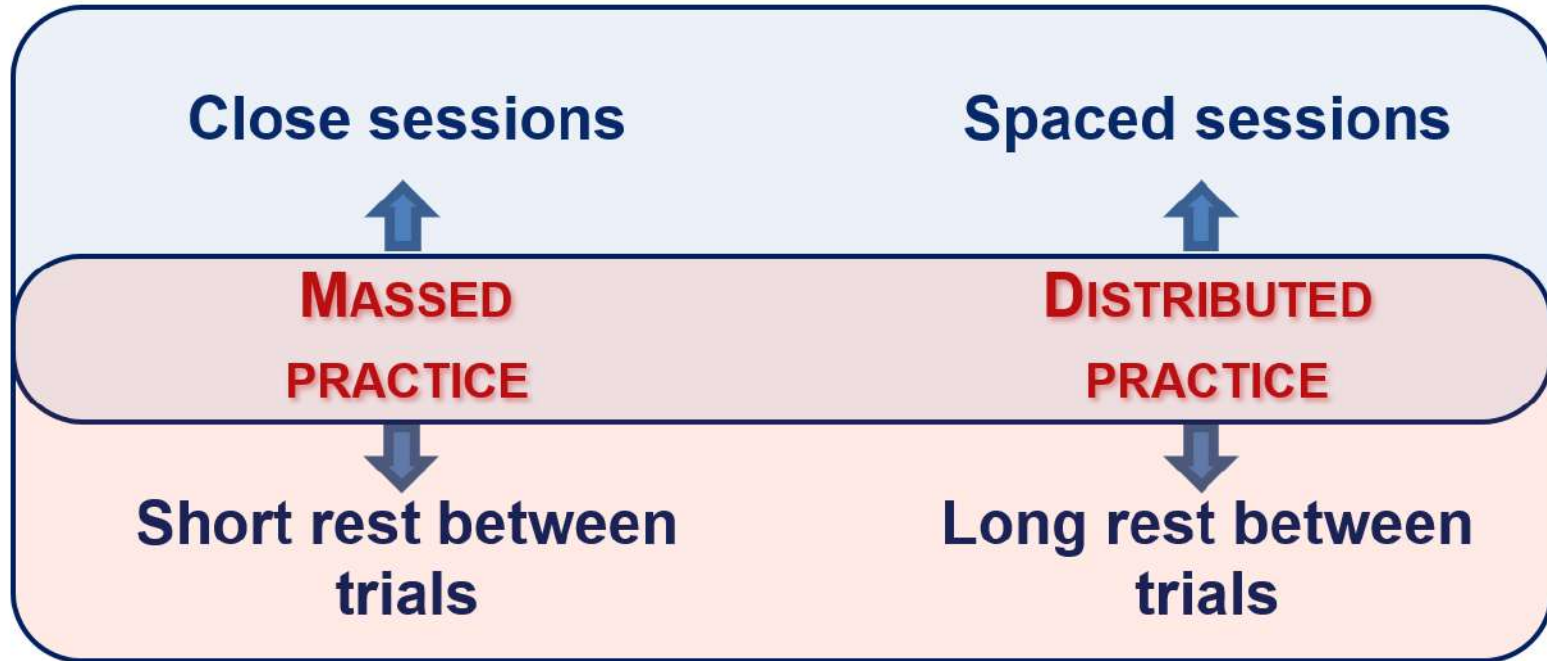
**MASSED
PRACTICE**

**DISTRIBUTED
PRACTICE**

Within a session

Short rest between trials

Long rest between trials



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

Constant and variable practice

Constant practice

Skill performed in:

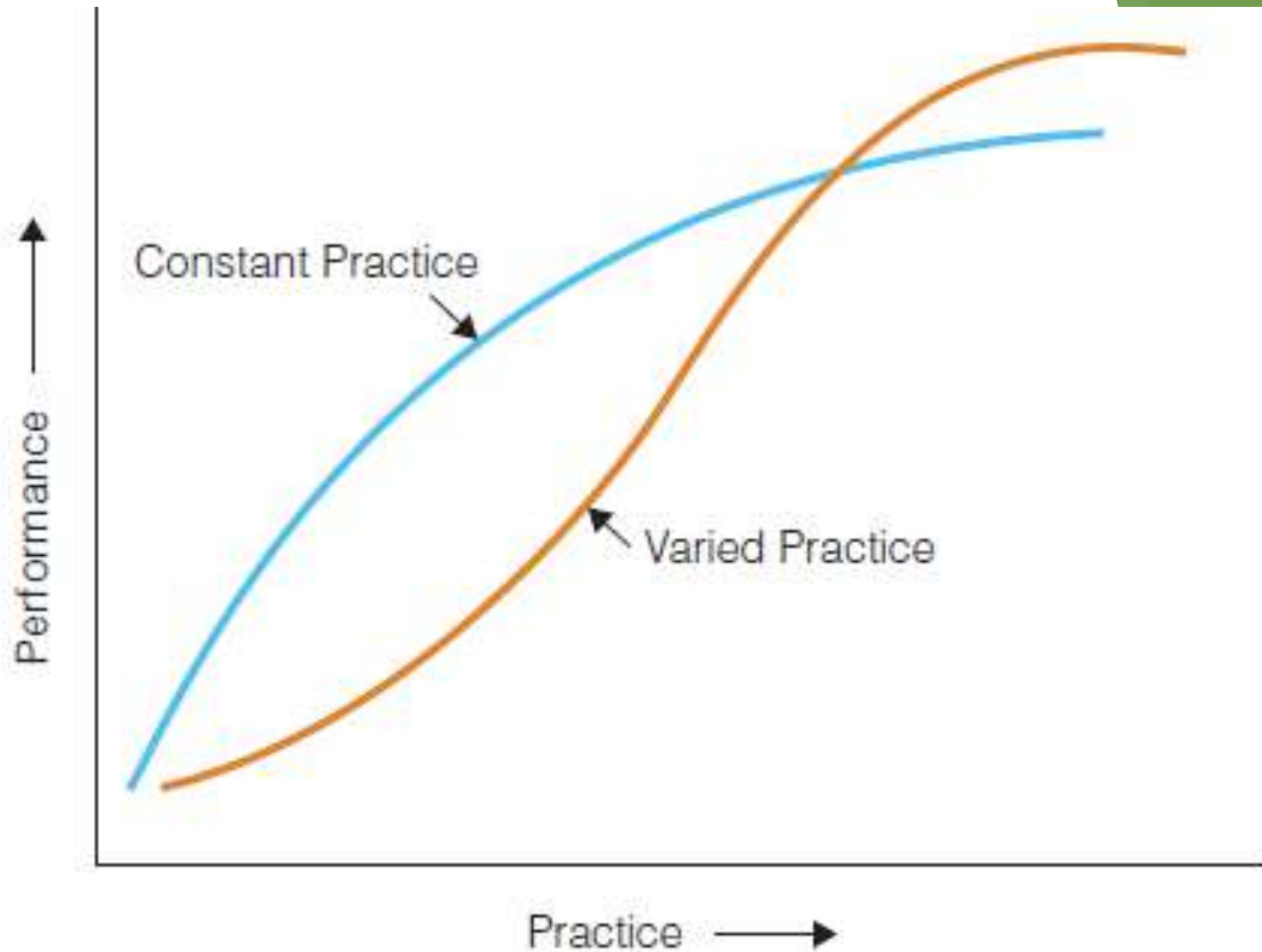
- same ways
- same conditions

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)

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

The learning benefit resulting from performing multiple skills in a high contextual interference practice schedule (i.e., random or serial practice), instead of

Blocked and random/serial practice

Blocked practice

Different skills performed
in blocks

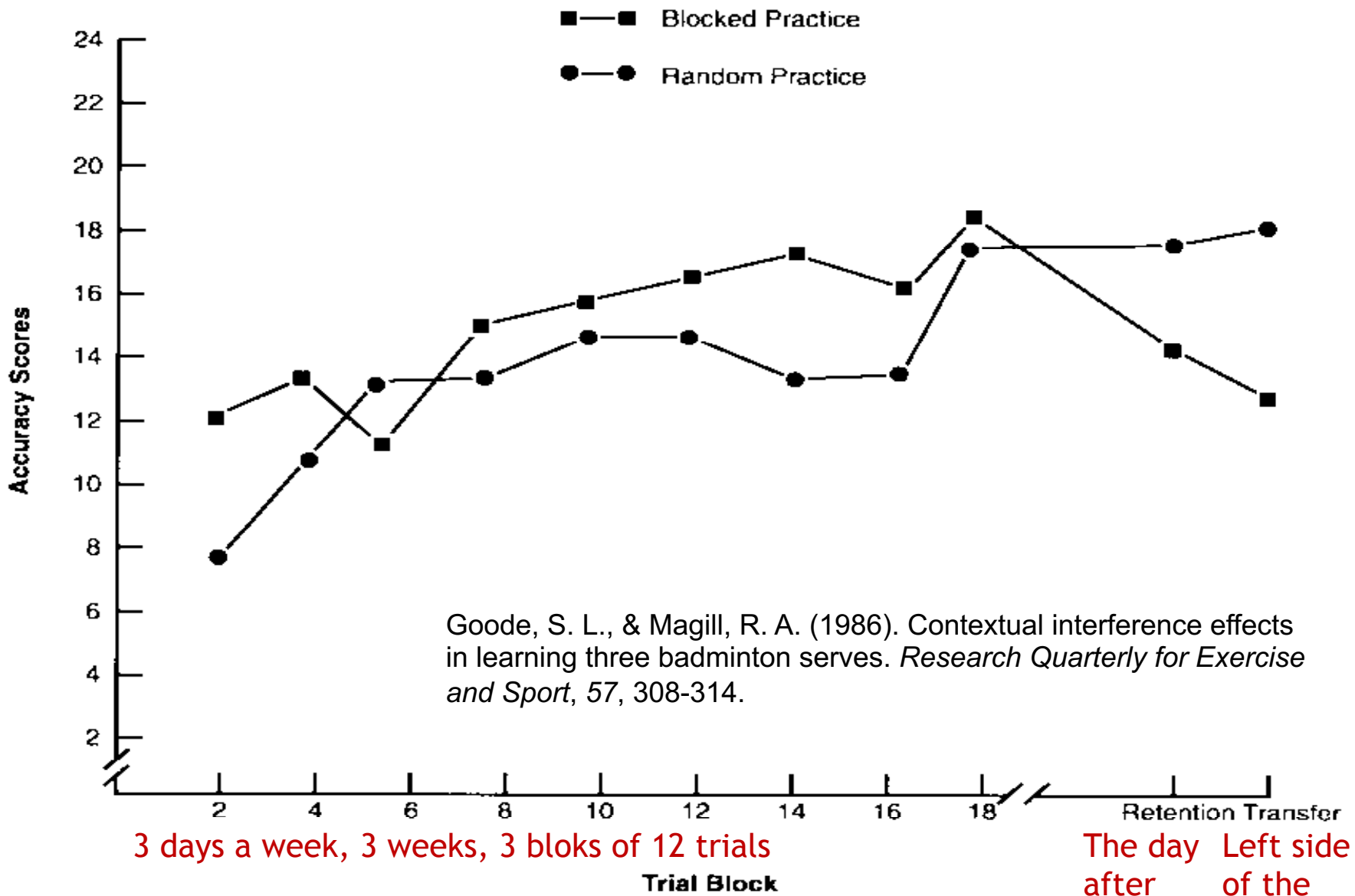
Low contextual interference

Random/serial practice

Different skills performed
in random or serial order

High contextual interference

The constant/variable practice continuum



Goode, S. L., & Magill, R. A. (1986). Contextual interference effects in learning three badminton serves. *Research Quarterly for Exercise and Sport*, 57, 308-314.

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. (short, long, and drive)

Random/serial practice - *contextual interference* -

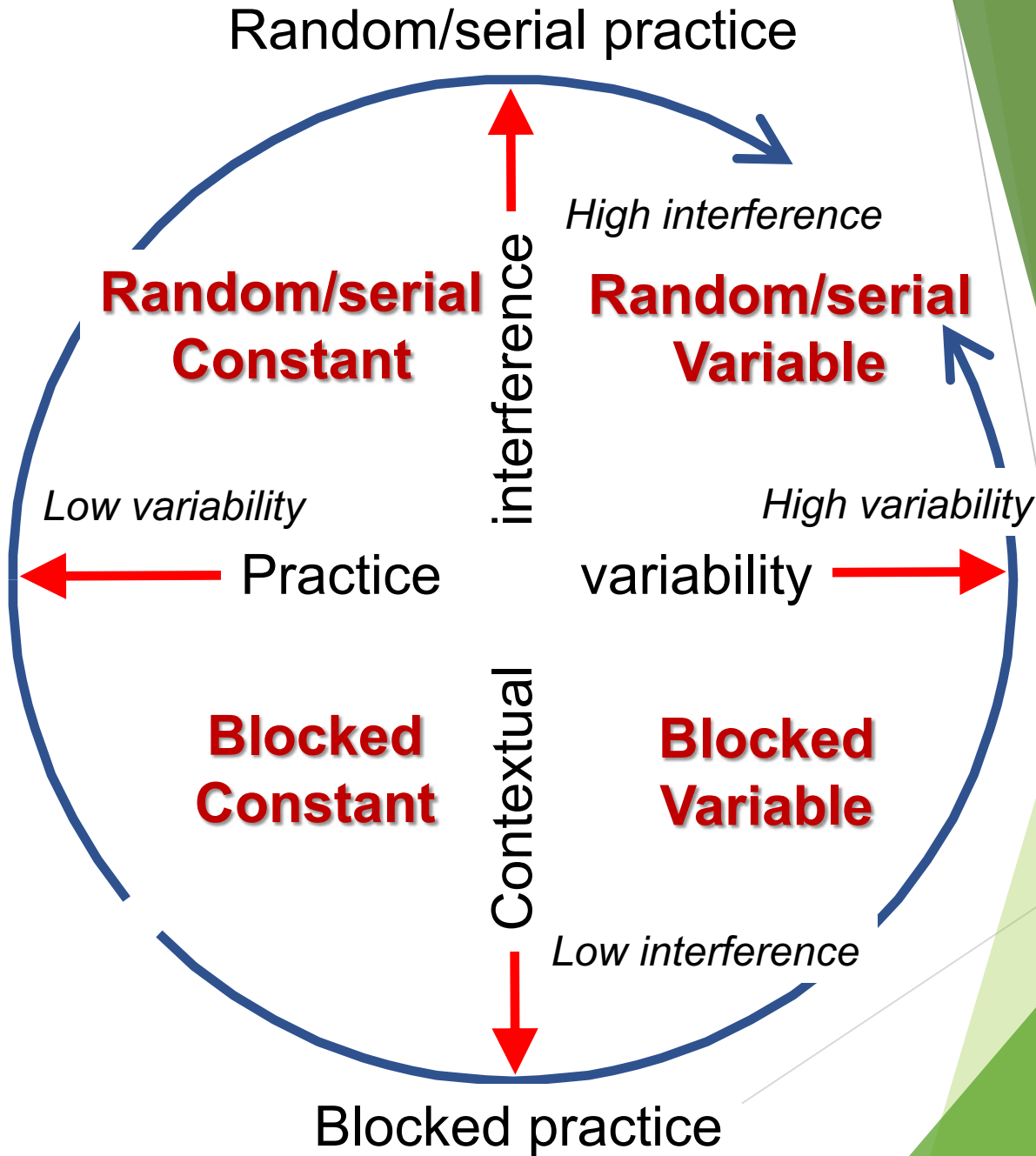
- elaboration hypothesis
- action plan reconstruction hypothesis



Greater attention
Cognitive effort

Combining
practice
variability
and
contextual
interference

Constant
practice



Variable
practice

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

**LOW
INTERFERENCE**



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

AAAAAAAAAAAA BBBB BBBB BBBB BBBB CCCCCCCCCCCC

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

A₁A₂A₃A₁A₂A₃A₁A₂A₃A₁A₂A₃ B₁B₂B₃B₁B₂B₃B₁B₂B₃B₁B₂B₃
C₁C₂C₃C₁C₂C₃C₁C₂C₃C₁C₂C₃

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**

A₁A₂A₃B₁B₂B₃C₁C₂C₃ A₁A₂A₃B₁B₂B₃C₁C₂C₃
A₁A₂A₃B₁B₂B₃C₁C₂C₃ A₁A₂A₃B₁B₂B₃C₁C₂C₃

Example with pistol shooting skills

Blocked-constant practice

The simplest condition

- 1) **Lifting:**
15 rep, no var
- 2) **Sighting:**
15 rep, no var
- 3) **Triggering:**
15 rep, no var

Total: 45 rep

Blocked-variable practice

Intermediate difficulty

- 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

Total: 45 rep

Serial-constant practice

Intermediate difficulty

- 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

Total: 45 rep

Serial-variable practice

The most challenging

- 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

PART VS WHOLE PRACTICE

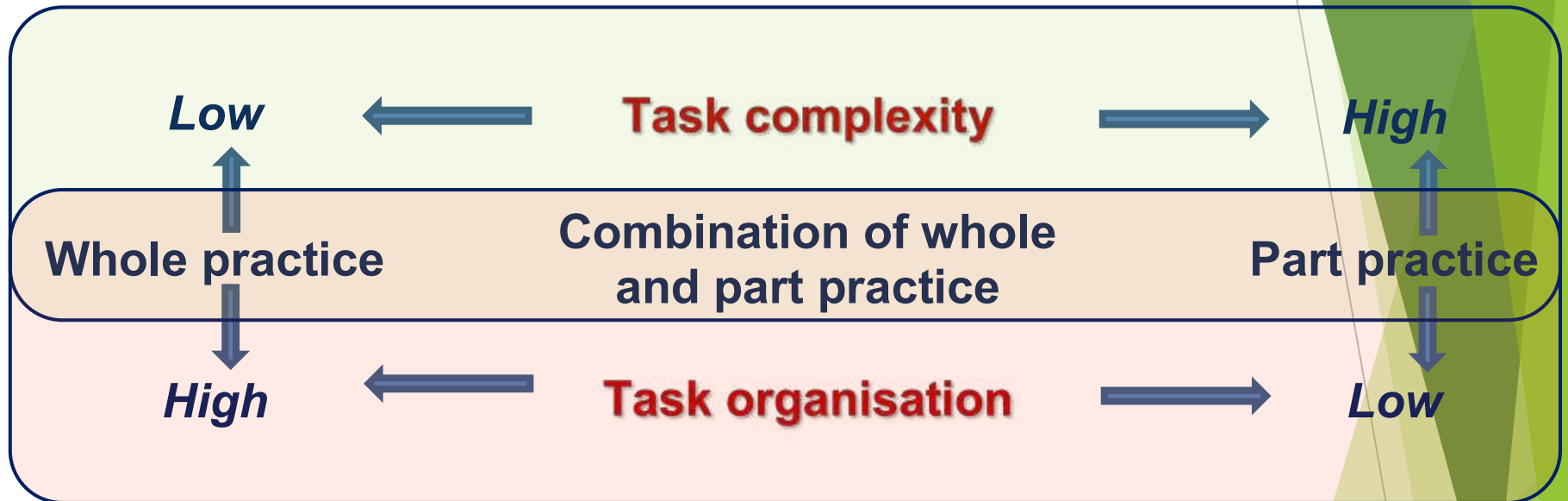
Part practice

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.

Whole and part practice



Whole and part practice

- whole-part-whole practice
- segmentation
- progressive part practice
- attentional cueing
- simplification

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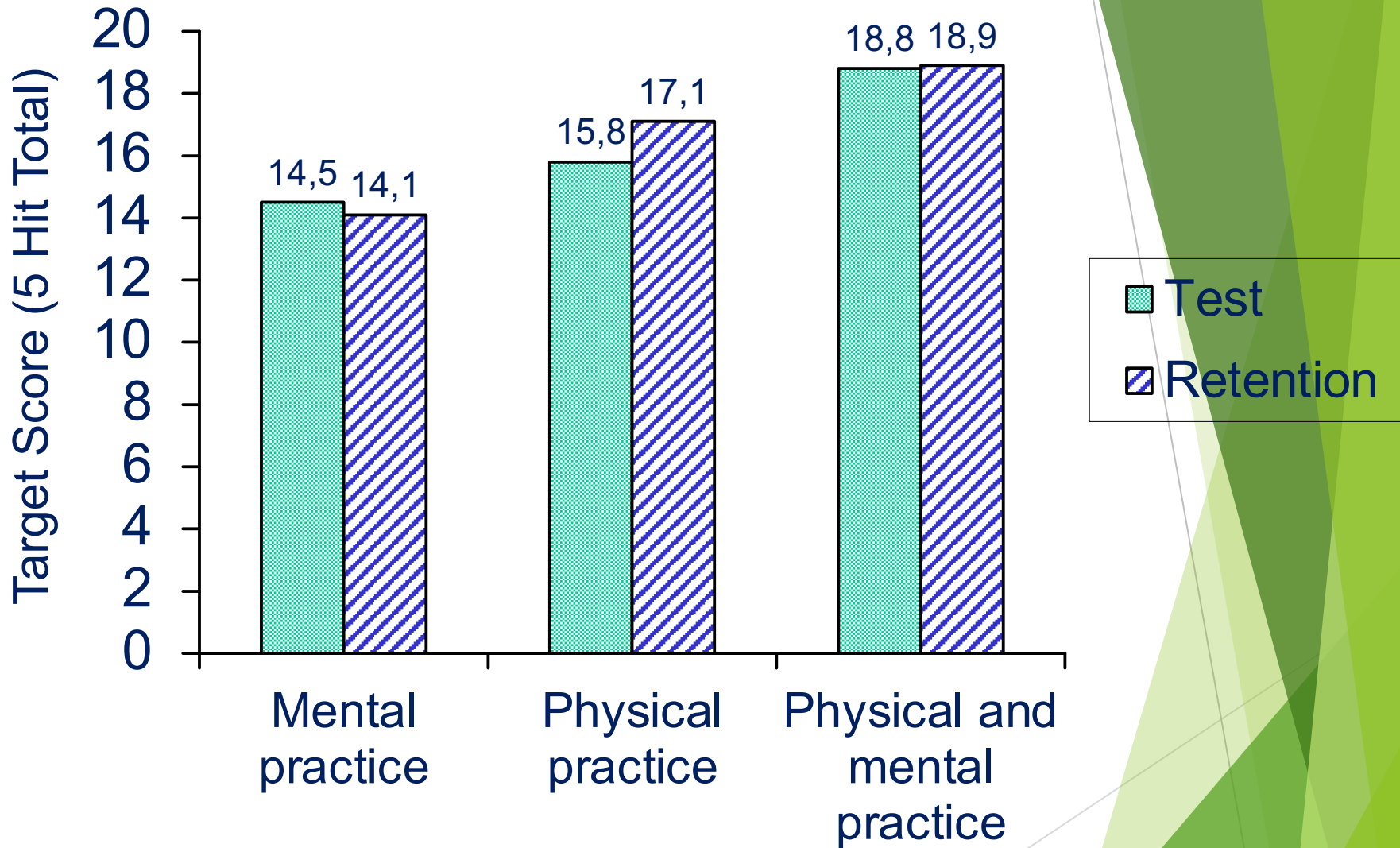
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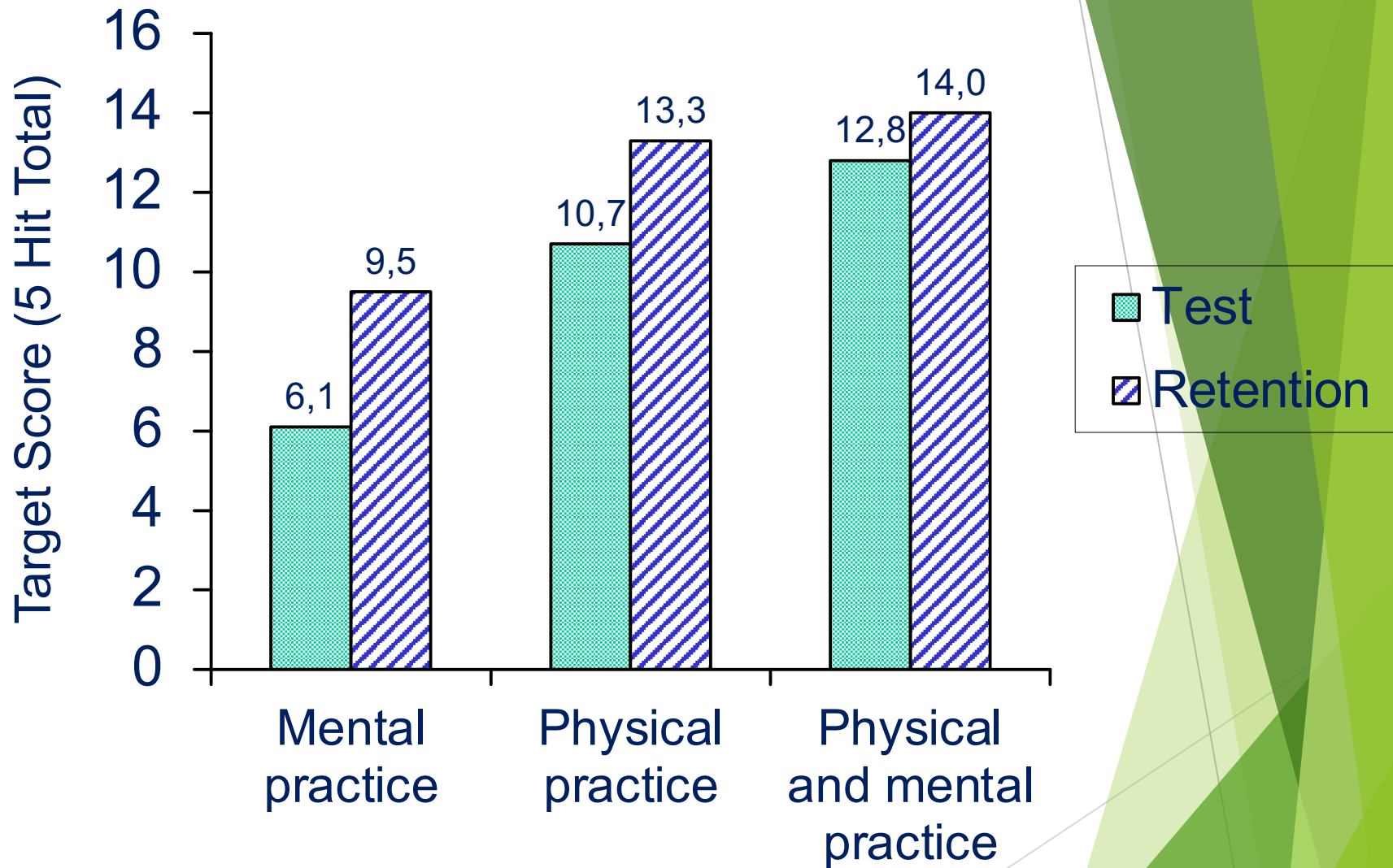
- The PETTLEP model
- Performance routines
- The five-step strategy
- Identifying the core components of the action

Closed 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 closed motor skill

Open 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 an 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

Imagery 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**

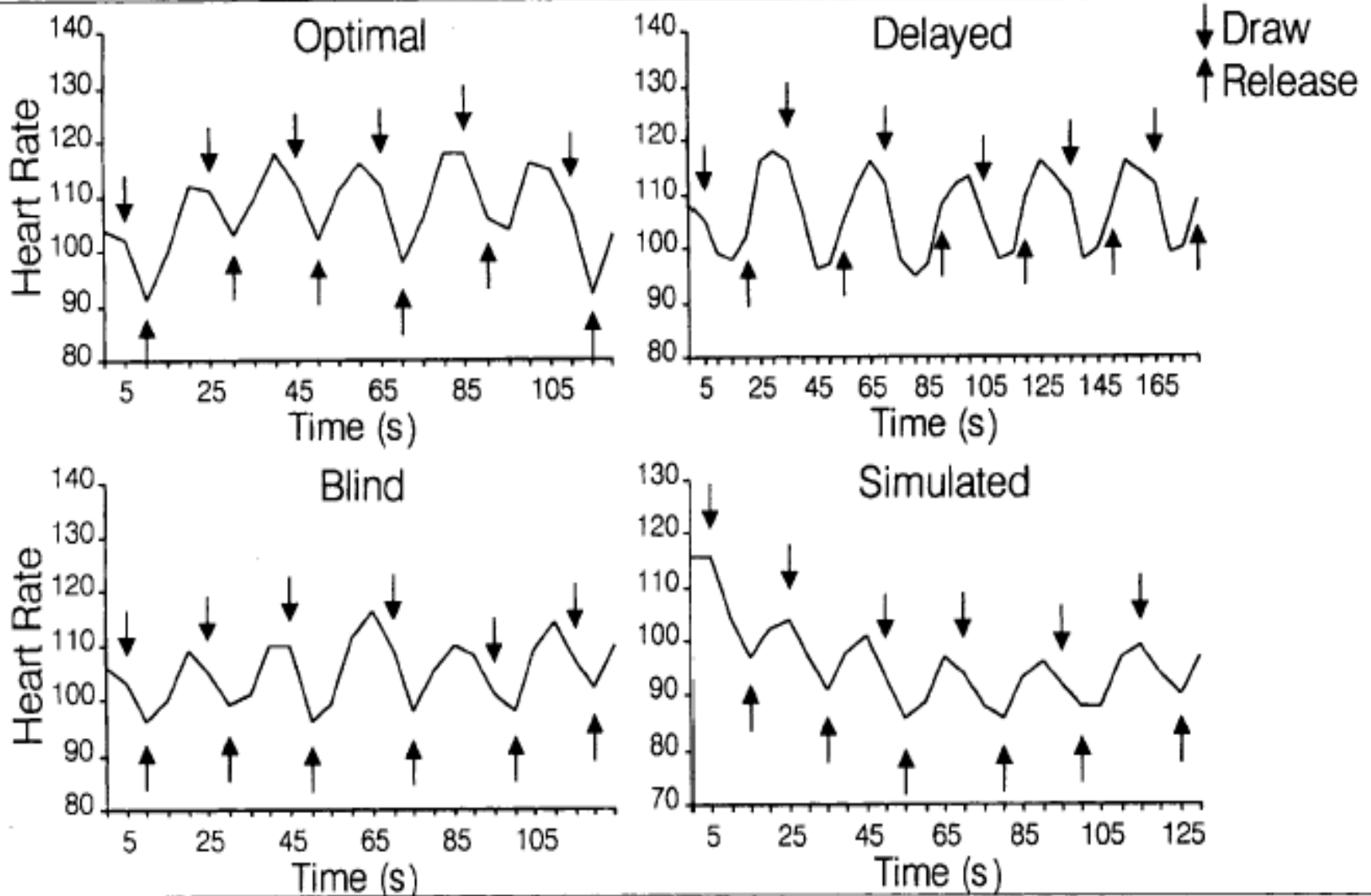


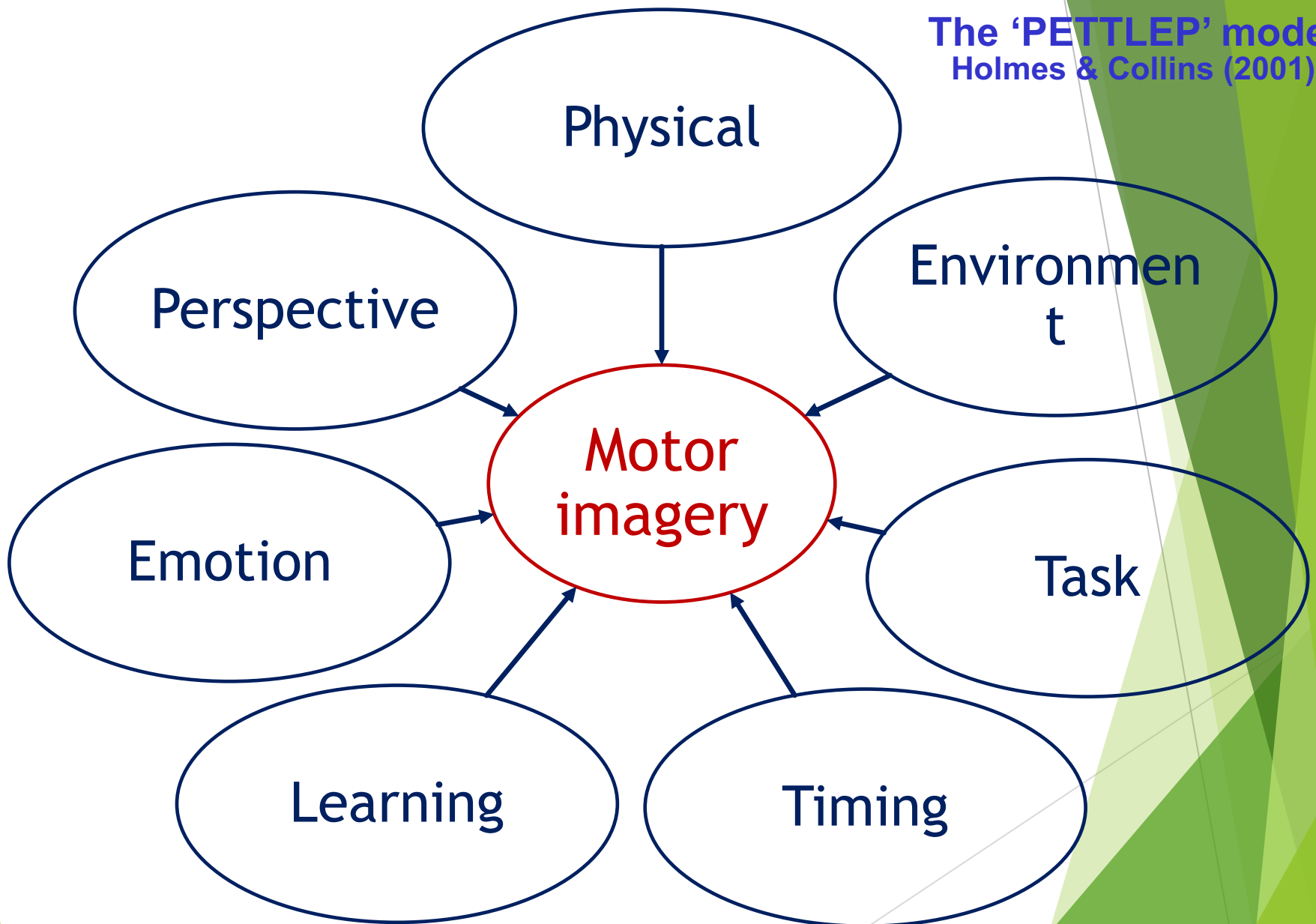
Figure 1
Heart rate, 5-s sampling, of an archer under different treatment conditions.

Robazza, C., Bortoli, L., & Nougier, V. (1998). Physiological arousal and performance in elite archers: A field study. *European Psychologist*, 3, 263-270.

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

Physical	All imagery should be performed in the way you would shoot
Environment	Cues of the actual environment
Task	Focus on meaningful aspects of shooting
Timing	Imagery movements in real time as much as possible
Learning	Imagery should progress with physical skill development
Emotion	Awareness of own emotional reactions
Perspective	Internal & external

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).

Prepare

1. Readyng

2. Imaging

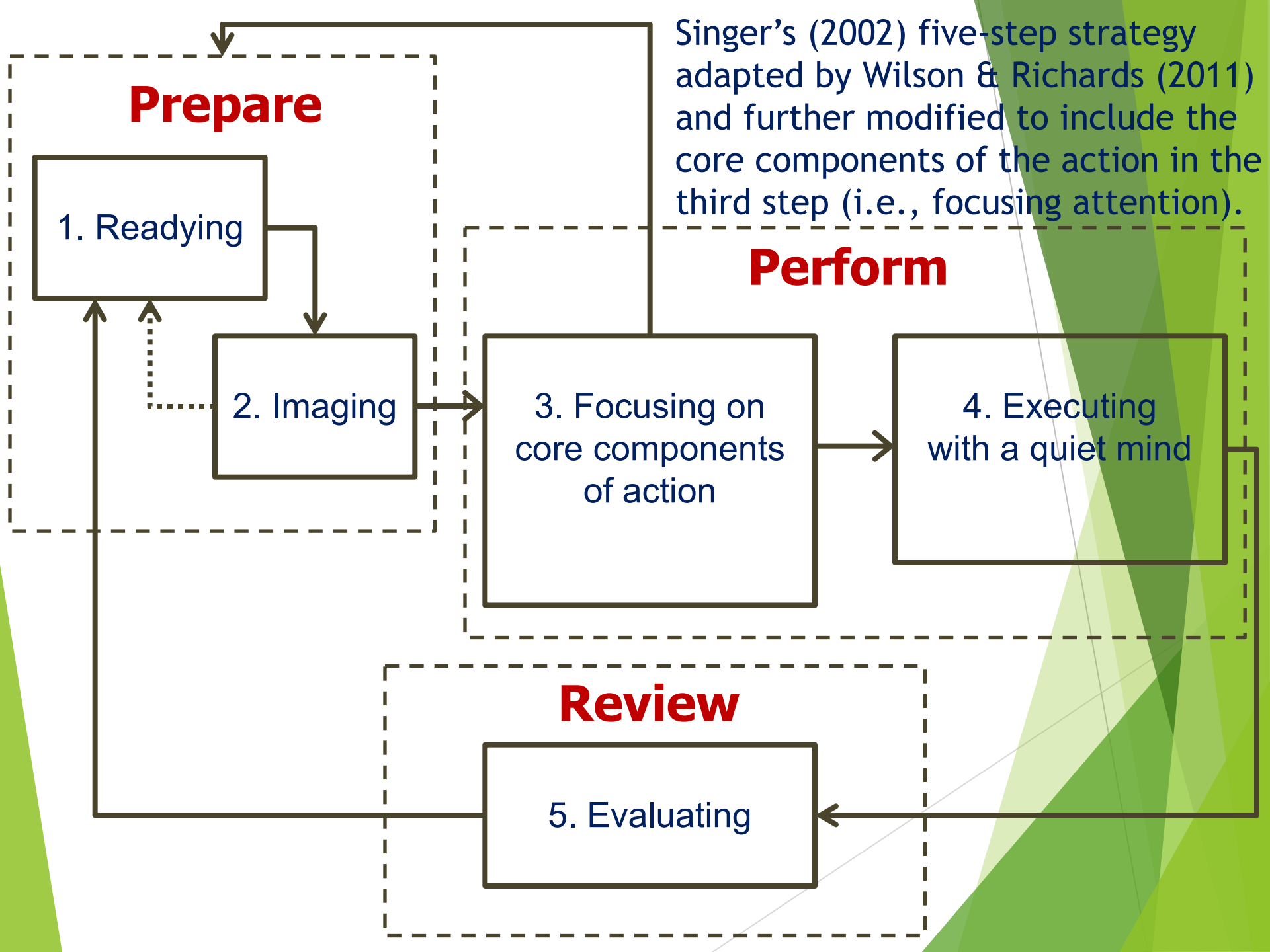
3. Focusing on
core components
of action

4. Executing
with a quiet mind

Review

5. Evaluating

Perform



The multi-action plan (MAP) model

Optimal performance

Type 2

Monitoring
Effective control
Effective focus
High energy

Supervision
Automated execution
Efficient & effective focus
Optimal energy

Type 1

High

monitoring/
control

Perf self-reg

monitoring/
control

Low

Type 3

Over control
Focus disruption
Energy misuse

Perf self-reg

Low control
Lack of focus
Low energy

Type 4

Suboptimal performance

The multi-action plan (MAP) model

Core components of action

Fundamental movements

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

or action-related behaviors

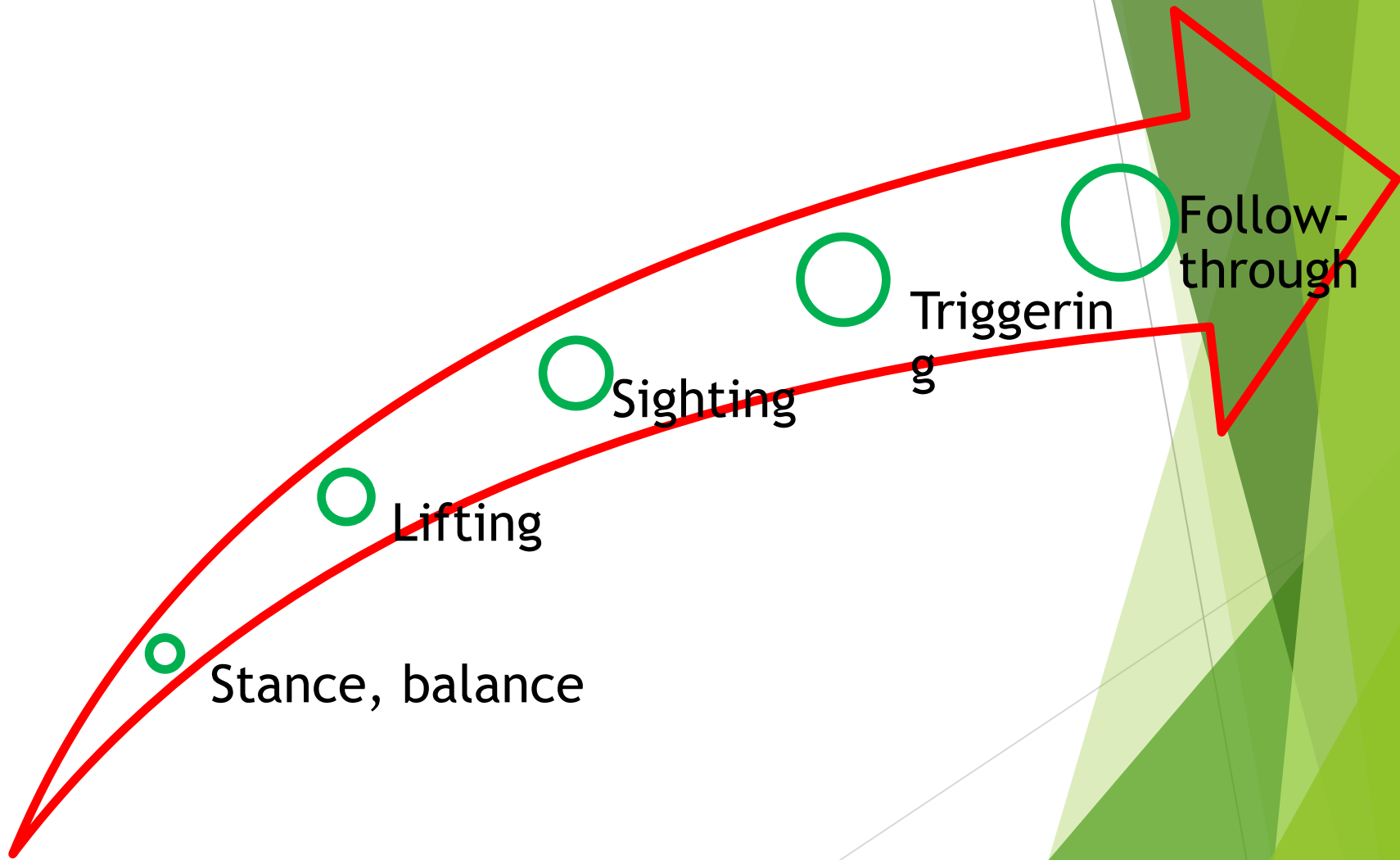
– *e.g., intensity, effort, timing, acceleration, rhythm of
movement –*

**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

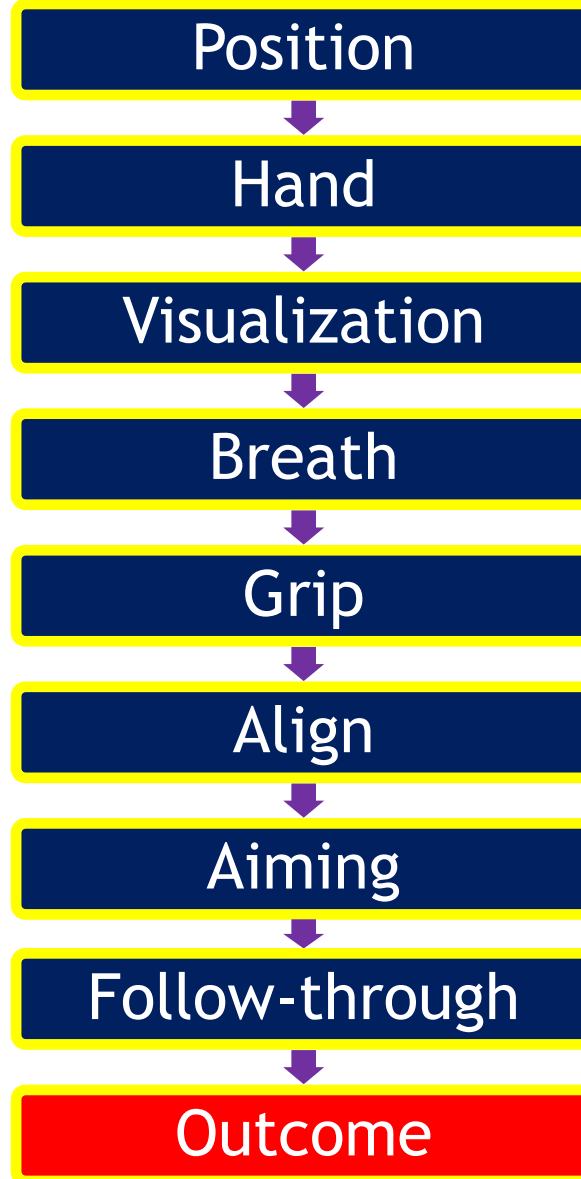


Example in shooting

Step 1

Athlete's description of usual optimal sequence of a single shot from start to follow-through

Pistol shooter



Example in shooting

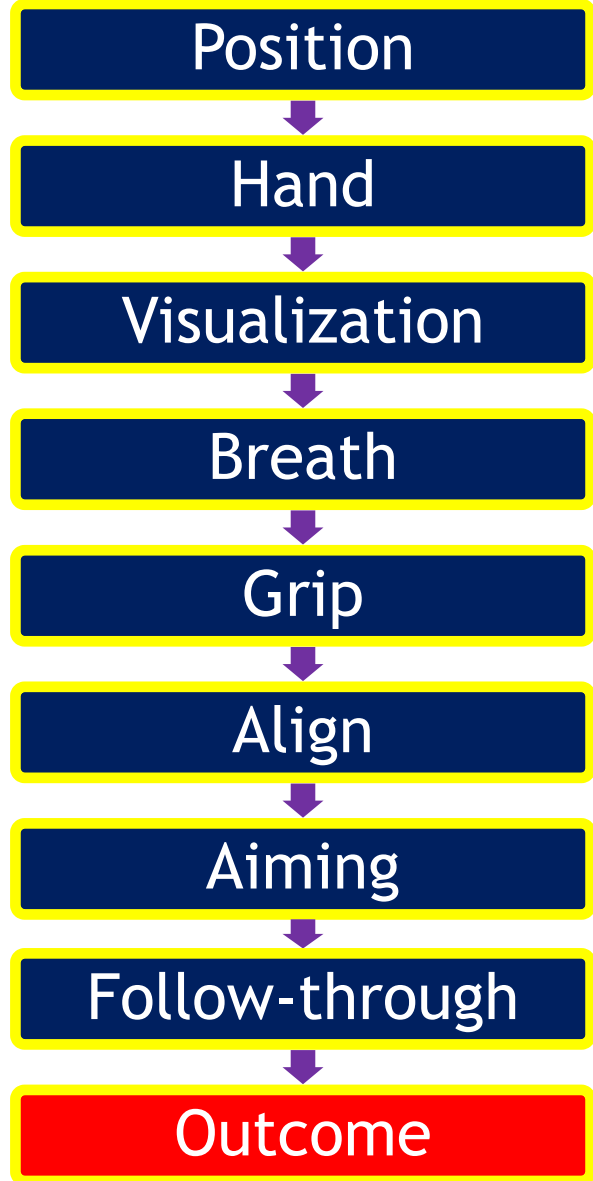
Step 2

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



Example in shooting

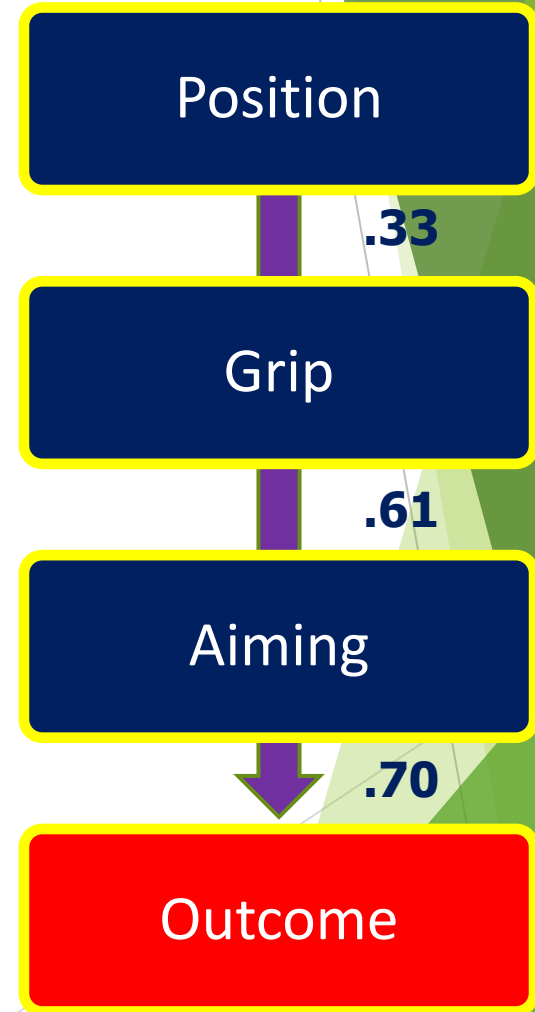
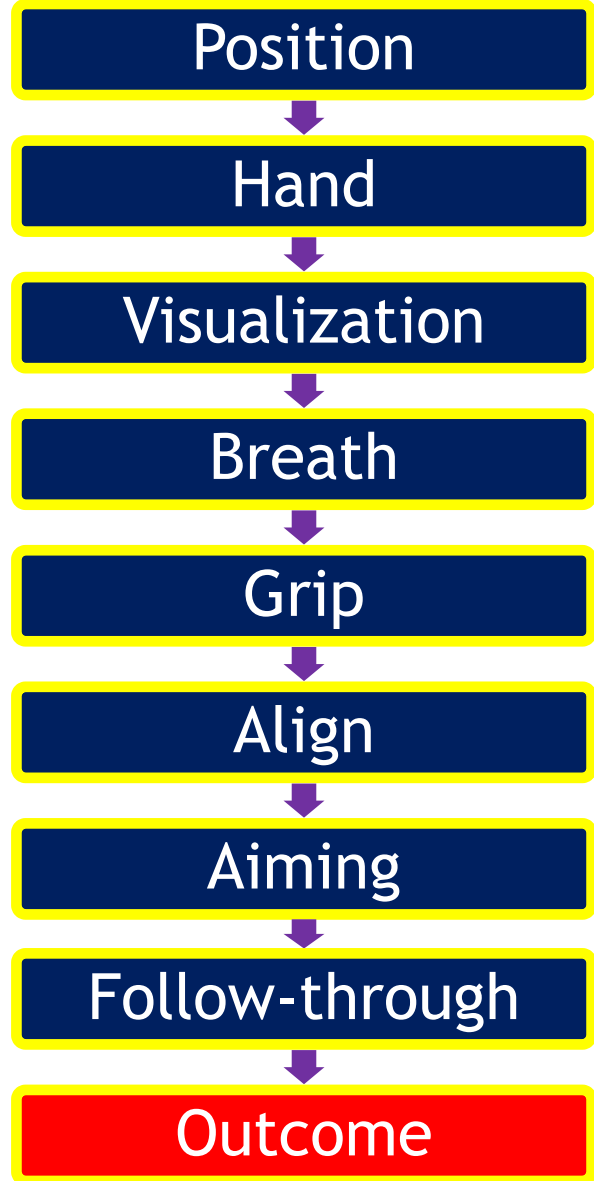
Step 3

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
	4
much	5
	6
very much	7
	8
	9
very, very much	10
maximum possible	#

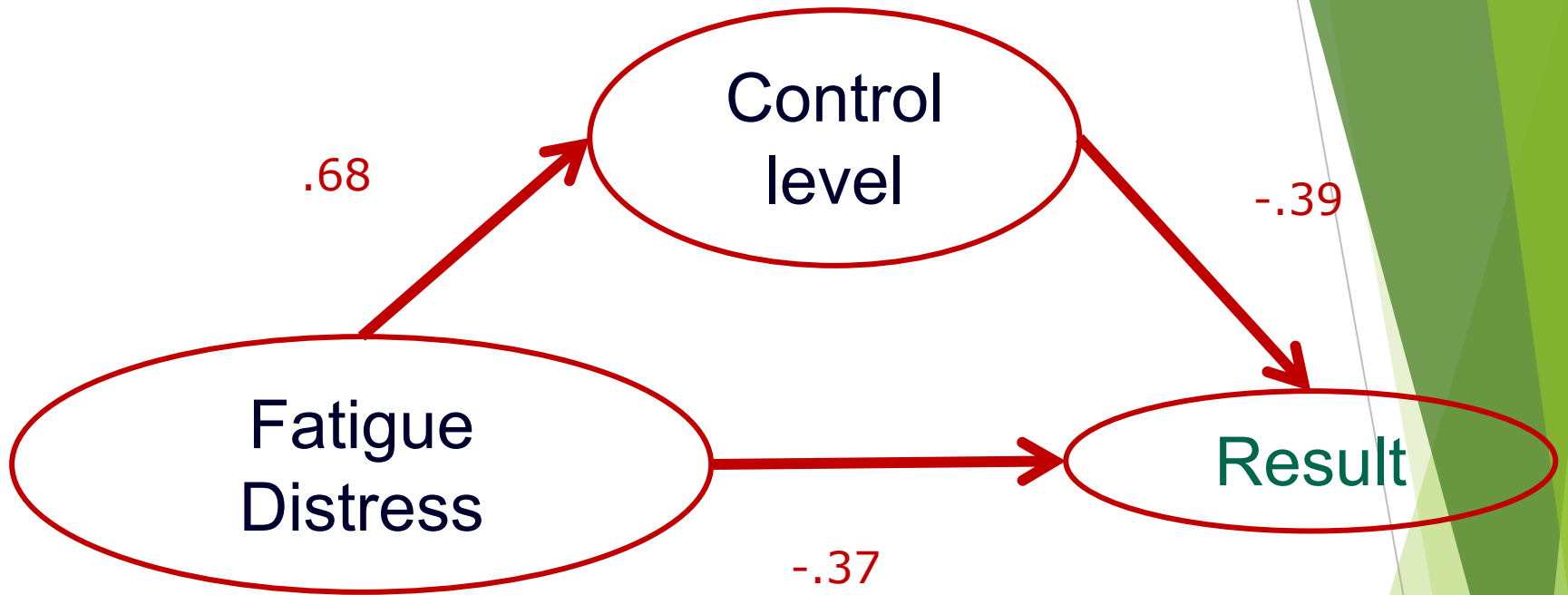
Pistol shooter



Example in shooting

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

Optimal performance

High
control

Minimal
control

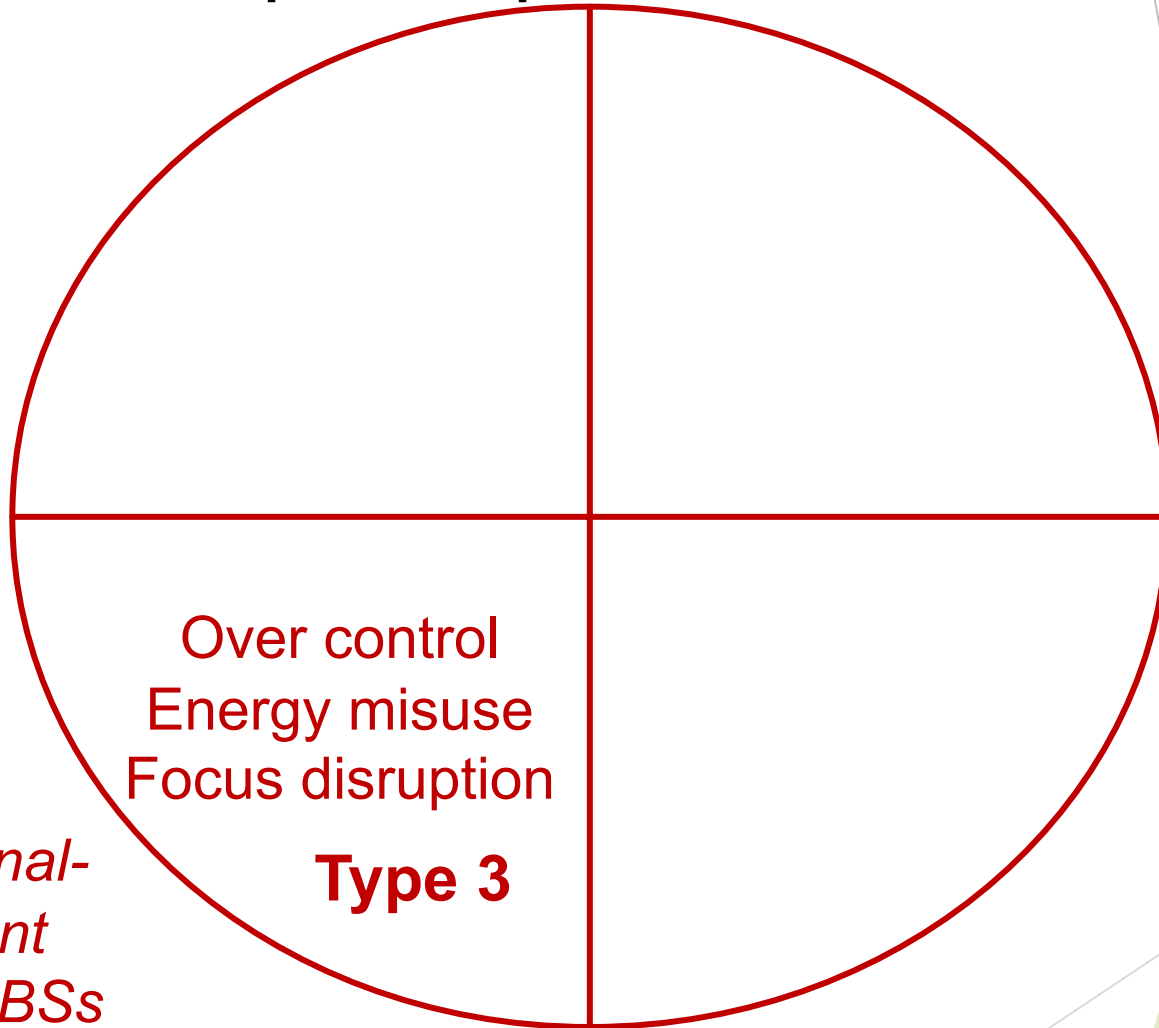
Over control
Energy misuse
Focus disruption

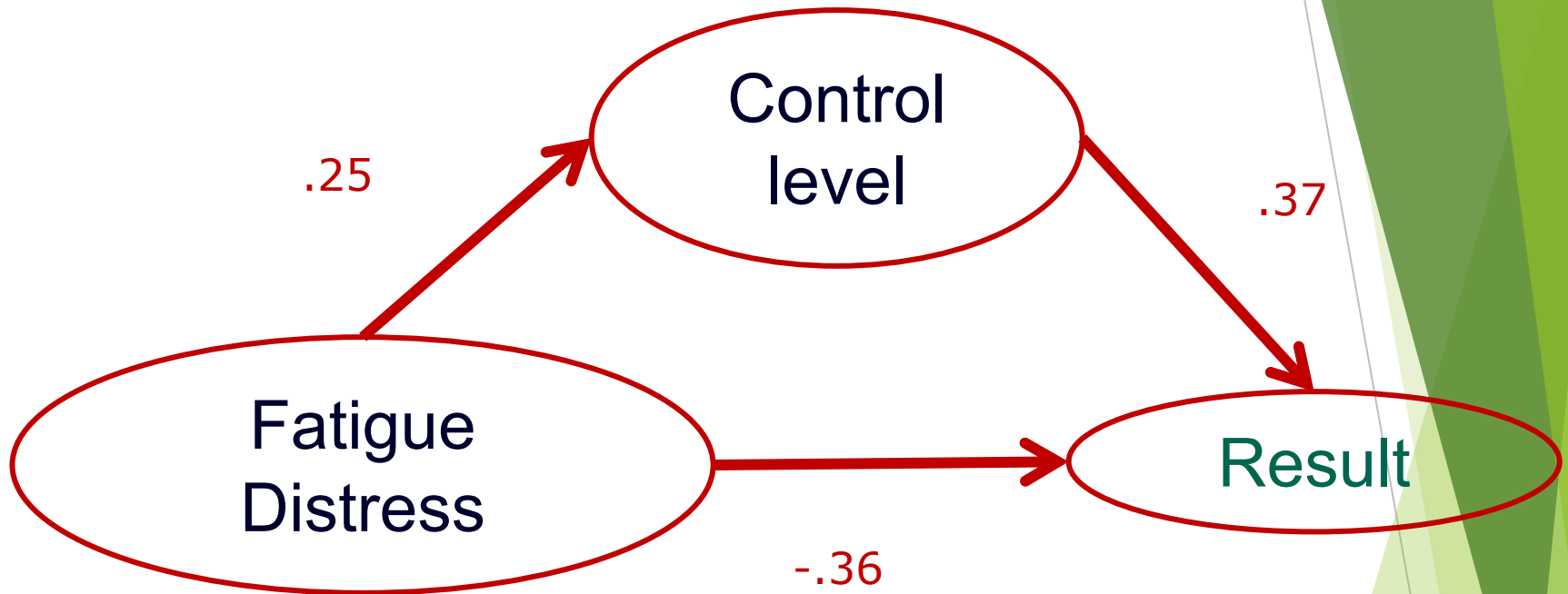
Type 3

*Dysfunctional-
unpleasant
emotions/PBSs*

(U-)

Suboptimal performance





Type 2 performance: Shooter with effective strategy

Optimal performance

*Functional-
unpleasant
emotions/PBSs
(U+)*

Type 2

Control
High energy
Effective focus

High
control

Minimal
control

Suboptimal performance

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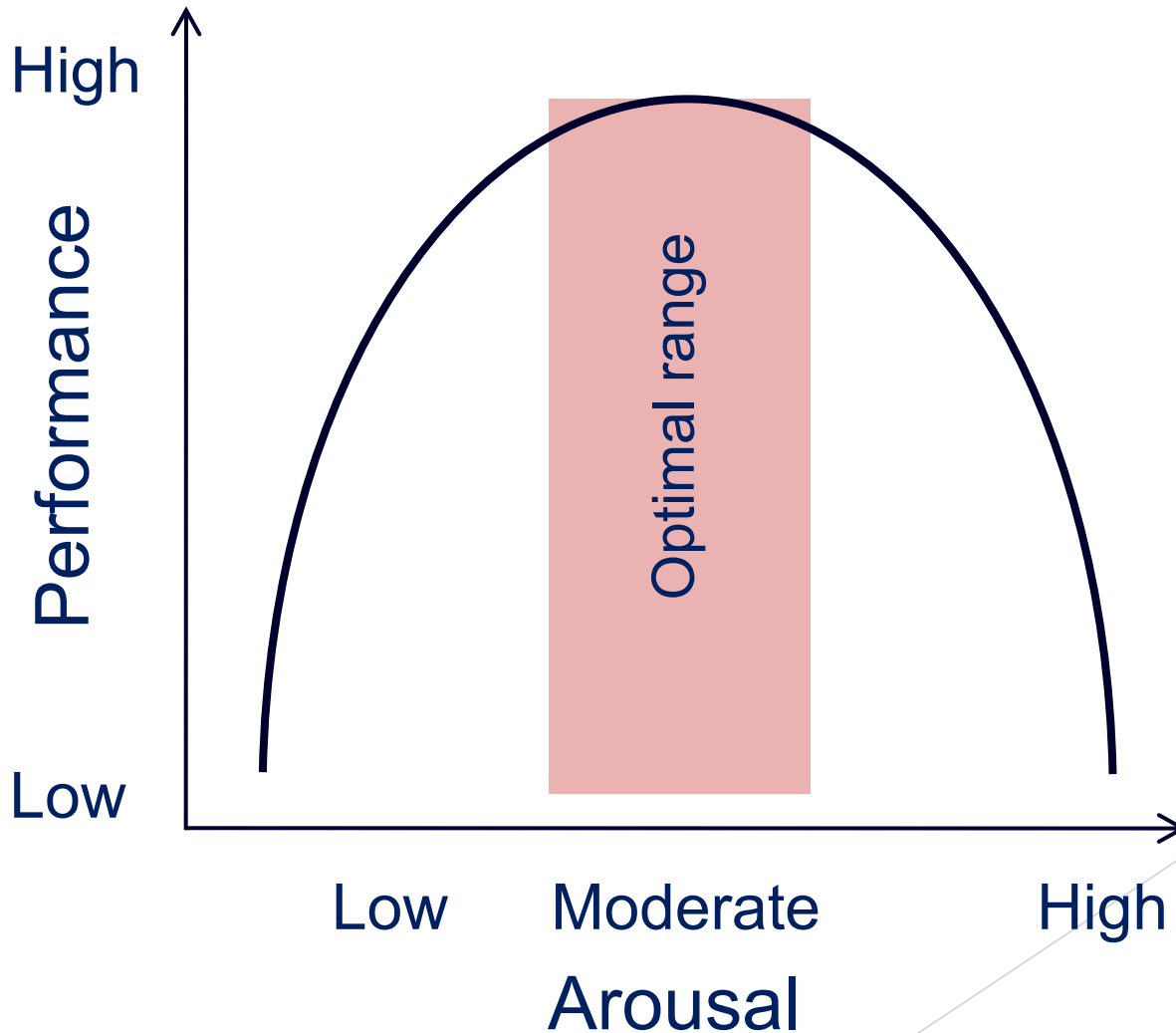
- Breathing
- Muscle tension/relaxation
- The relaxation response

Arousal

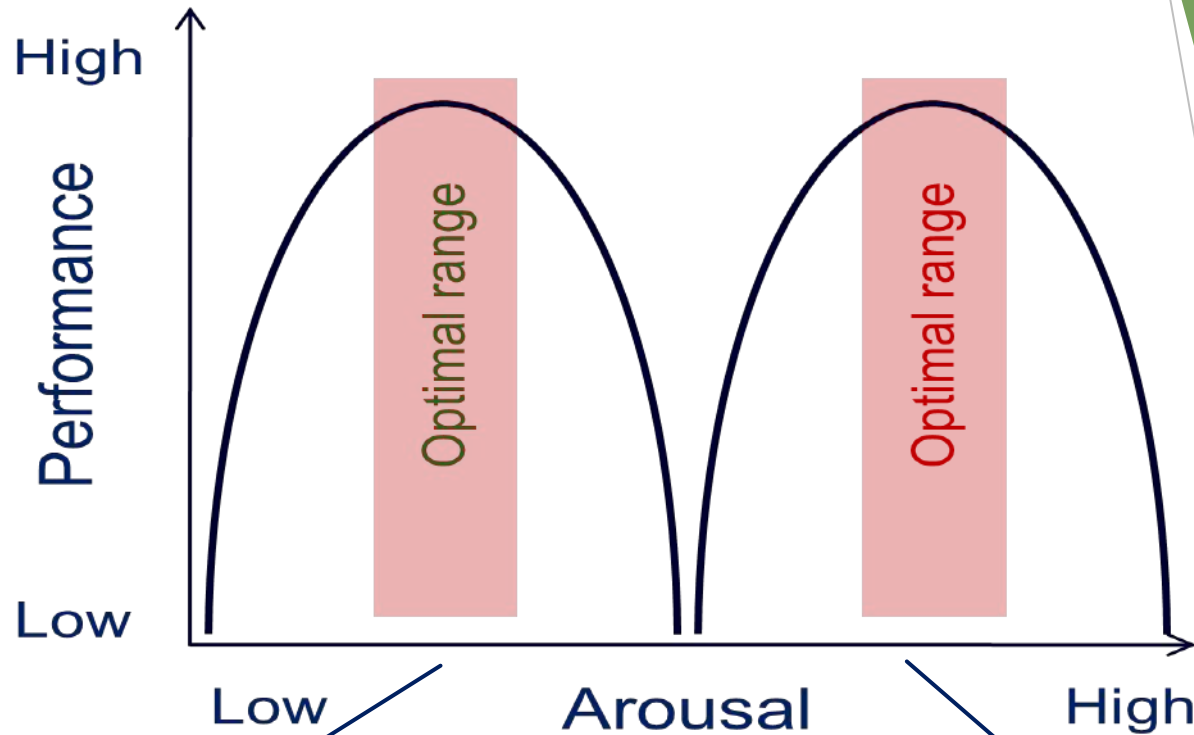
Definition:

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

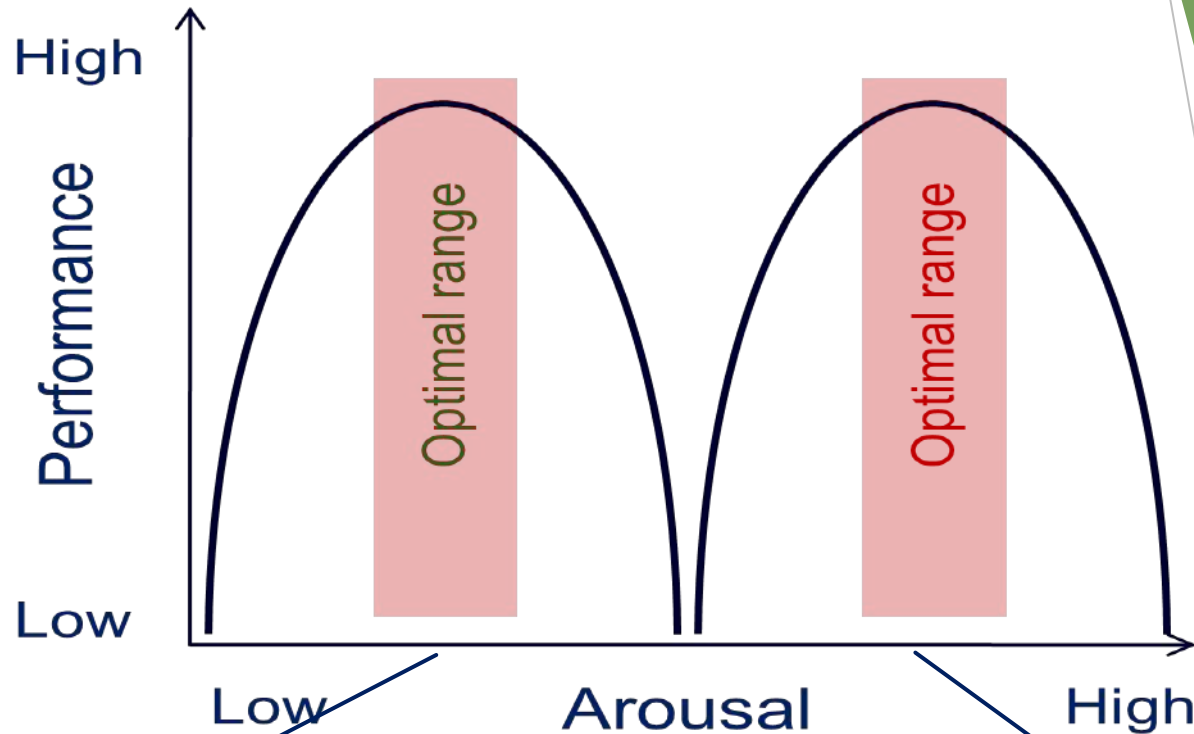
arousal:

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

Breathing techniques (2/2)

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

