Motor learning

Motor learning and motor control is the science that explains *how* humans learn to move, *how* movements become skilled, and *why* some individuals perform with exceptional precision while others struggle.

Every time you tie your shoes, sprint on a track, type on your phone, or adjust your balance when someone bumps into you, you are engaging in a sophisticated system of **perception, decision-making, coordination, and action**. And the most fascinating part? **You were not born knowing any of these skills—you learned them.**

Motor learning is the process that transforms awkward, shaky, error-filled attempts into smooth, accurate, and efficient performance.

Motor control is the invisible architecture—the neural and biomechanical mechanisms—that makes such learning possible.

This field answers questions like:

- Why does practice make perfect?
- Why do elite athletes move differently from beginners?
- How does the brain choose the right movement in a fraction of a second?
- How do we measure or classify skills in sports?

Motor learning

Motor learning is “defined as internal neural and cognitive processes concerning practice or experience leading to a relatively permanent change in performance.”

Motor learning is affected by cognition, active participation, area of brain affected/injured, frequency of feedback during new motor task, and working memory ability.

Motor learning is the study of the processes involved in acquiring motor skills and of the variables that promote or inhibit such acquisition.

In defining motor skills, we said that they are movement capacities that are learned rather than gained through normal growth and development.

Those factors influencing the learning of motor skills, whether through normal daily experiences or within formal instructional settings, entail the study of motor Learning.

Many factors influence the learning of motor skills, but it is common to classify them into three distinct categories.

These categories include the study of (1) the learner, (2) the skill to be learned, and (3) the conditions under which the skill is learned.

Motor control

Motor control involves the study of the neural, behavioral, environmental, and synergistic mechanisms responsible for human movement and stability.

All motor skills, regardless of the level of skill with which they are executed, are expressions of the motor control system. The final target of this system is the muscles and joints responsible for executing action.

Two outcomes of muscular control are paramount to motor control—the control of movements and the control of stability or posture.

motor control also is defined as; how our neuromuscular system functions to activate and coordinate the muscles and limbs involved in the performance of a motor skill.

Researchers may investigate this question while a person is learning a new skill or performing a welll earned or highly experienced skill,

The Learner

- Previous skill learning
- Level of motivation
- Age and developmental readiness
- Psychological characteristics
- Fitness level
- Bodily constraints on movement

Nature of the Skill

- Performed in isolation or with others
- Executed rapidly or over time
- Perceptual demands
- Stable or changing conditions
- Use of equipment
- Rules constraining action

Environment

- Predictability of environment
- Presence of observers
- Light, wind, surface conditions, etc.
- Environmental context (background. etc.)
- Constraints on movement possibilities
- Perceptual elements present in environment

Characteristics of Motor Learning

- Requires **practice and repetition**
- Involves **feedback and error correction**
- Leads to **improved accuracy, speed, and coordination**
- Changes occur in the **central nervous system**
- Results are **long-lasting**

Fitts and Posner's Three-Stage Model

The most widely used model of motor learning includes:

- **Cognitive Stage**
- **Associative Stage**
- **Autonomous Stage**

Stage 1: Cognitive Stage

Characteristics:

- Learner tries to understand **what to do**
- Movements are often slow and full of errors
- High attention and mental effort
- Learner needs **clear instructions and demonstrations**

Examples:

- Beginner learning to dribble
- First attempts at swimming

Stage 2: Associative Stage

Characteristics:

- Skill becomes **more refined**
- Fewer mistakes
- Better timing and coordination
- Learner can detect some errors independently
- Practice becomes more consistent

Examples:

- A tennis player practicing serves repeatedly
- A gymnast improving technique

Stage 3: Autonomous Stage

Characteristics:

- Skill becomes **automatic**
- Very little conscious effort required
- Movements are fast, efficient, and consistent
- Learner can focus on **tactics and strategy**

Examples:

- Professional athlete in competition
- Expert driver shifting gears without thinking

The Learning Journey: A Path to Automaticity

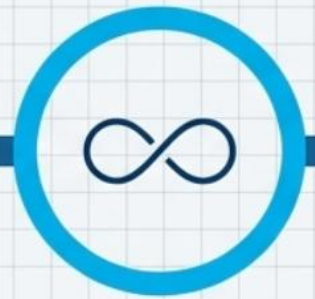
1. Cognitive Stage

Focus: “What to do?”
Characteristics: High cognitive activity, inconsistent performance, and numerous large errors.

2. Associative Stage

Focus: “How to do it?”
Characteristics: Refining the movement pattern, fewer and smaller errors, and decreased variability.

3. Autonomous Stage



Focus: “Doing it automatically.”
Characteristics: Skill is habitual with low attention demand, consistent performance with few errors.

Examples of Questions Studied by Motor Learning Theorists

- Should instructors demonstrate only how to perform skills correctly, or should errors also be demonstrated?
- Should beginners be taught how to analyze their movement errors?
- Should a performer focus attention on his or her bodily movements?
- How can a coach or instructor estimate an individual's potential for learning a particular skill?
- When should part practice be used in teaching skills?
- Are there recognizable stages in the process of skill learning?

Domain	Starting Age	Years to International Performance	Age at Peak Performance
Tennis	6.5	10+	18 to 20
Swimming	4.5	10	18 to 20
Piano	6	17	NA
Chess	10	14	30 to 40

Source: Adapted from Ericsson, KA. (1990). "Theoretical issues in the study of exceptional performance." In KJ Gilhooly, MTG Keane, RH Logic, and C Erdos (eds.), *Lines of thinking: Reflections on the psychology of thought* (vol. 2). Mahwah, NJ: Lawrence Erlbaum.

Skills

When defining a skill, our first decision entails deciding whether cognitive, perceptual, or motor capabilities are most necessary to the successful completion of the skill.

skill :an activity or task that has a specific purpose or goal to achieve; (b) an indicator of quality of performance.

Cognitive Skills

A **cognitive skill** is one in which knowing what to do or how to do it is the most important aspect in accomplishing the skill. Although perceptual and motor elements may make up part of a cognitive skill, understanding and knowing are the most essential capabilities for doing the skill well, and are usually the most difficult to master. We can define a cognitive skill "as one in which success in accomplishing the goals of the skill is primarily determined by an individual's knowledge and cognitive abilities". ,

Perceptual Skills

A perceptual skill is one in which the ability to discern, or to discriminate among, sensory stimuli is of primary importance in accomplishing the skill successfully. More simply stated, it is the ability to recognize important things in the environment—that is, to detect information. In accomplishing a perceptual skill, the primary goal of the performer is not in possessing the movement capabilities necessary for acting, but in sensing when and how to act.

Motor Skills

motor skills activities or tasks that require voluntary control over movements of the joints and body segments to achieve a goal.

CLASSIFICATION OF MOTOR SKILLS

Motor skills can be classified using **several dimensions**, each highlighting different performance characteristics.

1. Size of primary musculature required

Gross Motor Skills
Primary musculature required = Large muscles

Walking
Hopping
Jumping

Primary musculature required = Large and small muscles
Pitching a baseball
Shooting an arrow in archery
Putting a golf ball

Fine Motor Skills
Primary musculature required = Small muscles

Signing a check
Buttoning a shirt
Typing a word on a keyboard

2. Specificity of where actions begin and end

Continuous Motor Skills
Arbitrary beginning and end of the action; repetitive movements

- Steering a car
- Walking
- Swimming

Serial Motor Skills
Continuous series of discrete movements

- Playing a song on a piano
- Typing a sentence on a computer keyboard
- Shifting gears in a standard-shift car

Discrete Motor Skills
Specified beginning and end of the action; single movement

- Flipping a light switch
- Hitting a piano key
- Depressing the clutch pedal in a car

3. Stability of the environmental context

gross motor skill a motor skill that requires the use of large musculature to achieve the goal of the skill.

fine motor skill a motor skill that requires control of small muscles to achieve the goal of the skill; typically involves eye-hand coordination and requires a high degree of precision of hand and finger movement.

discrete motor skill a motor skill with clearly defined movement beginning and end points, usually requiring a simple movement.

continuous motor skill a motor skill with arbitrary movement beginning and end points. These skills usually involve repetitive movements.

serial motor skill a motor skill involving a series of discrete skills.

environmental context the supporting surface, objects, and/or other people or animals involved in the environment in which a skill is performed.

closed motor skill a motor skill performed in a stationary environment where the performer determines when to begin the action.

open motor skill a motor skill performed in a moving environment where the feature of the environmental context in motion determines when to begin the action.

The Environment Dictates the Action: The Open-Closed Skill Continuum

CLOSED SKILLS

OPEN SKILLS

Golf Shot — Tennis Serve — Soccer Shot

Performed in a stable, predictable environment where relevant environmental context features are stationary.

The performer initiates the action, free from external timing demands.

Examples: Hitting a golf ball off a tee, buttoning a shirt, climbing a flight of stairs.

Performed in a changing, unpredictable environment where the performer must act according to the requirements of the environmental context.

The performer must react to environmental changes, which often dictate the timing of the action.

Examples: Hitting a pitched baseball, walking through a crowded mall, catching a thrown ball.

المهارات المغلقة	المهارات المفتوحة
يتعامل اللاعب مع الأدوات	يتعامل اللاعب مع المنافس
هناك وقت كافي للأداء	الأداء والوقت معتمدان على أداء المنافس
يعتمد على السيطرة والضبط الحركي ولا يستخدم التوقع	يعتمد على التوقع وعلى حركة المنافس
لا يحتاج الى رد فعل سريع او استجابة سريعة	يحتاج الى رد فعل سريع او استجابة سريعة
ان الذكاء ليس عاملا أساسيا في الأداء	ان الذكاء واستراتيجية التفكير عاملا أساسيا في الأداء

Factors That Influence Skill Learning in Motor Learning

- **Primary Factors:**
- **Comprehension (Understanding) الاستيعاب**
- **Clarity- الوضوح**: clarity of the theoretical material and its practical applications in terms of explanation and presentation
- **Simplicity and Progression السهولة والتدرج** (easy-to-difficult sequencing)
- **Interest and Excitement التشويق والاثارة**
- **Motivation (Drive) and Reinforcement. الحوافز والتعزيز**
- **Maturity النضج**
- **Practice and Training الممارسة والتدريب (Experience)الخبرة**
- **Readinessالاستعداد**

Secondary Factors:

- **Heredity (Genetics) الوراثة**
- **Illness (Disease)المرض**
- **Disability**, which includes several forms:
  - **Physical disability** (temporary physical injury and chronic physical impairment)
  - **Cognitive/intellectual disability**

Psychomotor Factors Affecting the Learner and Motor Learning (Personal Considerations):

1. **Experience الخبرة**
2. **Personality الشخصية**
3. **Gender الجنس**
4. **Attitude الموقف**
5. **Motivation الدافعية**
6. **Intelligence الذكاء**
7. **Emotions العواطف او الانفعالات**
8. **Sensory Perception الادراك الحسي**
9. **Physical Measurements (body measurements) القياسات الجسمية**
10. **Quick-wittedness (Insight) – a type of perception الفطنة او اليقظة**
11. **Body Composition التركيب الجسمي**

Feedback

Feedback in motor learning refers to information about the execution of a motor action that is provided to the learner during or after the performance of a skill. This information can arise from the learner's own sensory systems or from external sources, such as a coach or technological aid. In essence, feedback is the cornerstone of effective skill acquisition, serving as a critical component that connects the sensory experience of action with the motor response. The importance of feedback lies in its ability to:

1. Direct Attention: Feedback helps learners focus on key aspects of the skill that need improvement, directing their attention and refining their motor control efforts.

2. Facilitate Error Correction:By providing insights into performance discrepancies, feedback allows learners to make adjustments and reduce errors.

3. Reinforce Learning:Positive feedback reinforces correct movement patterns, encouraging repetition and consolidation of the skill.

4. Motivate Learners: Feedback can act as a motivational tool, enhancing the learner's engagement and persistence with the task.

5. Promote Self-regulation: Over time, learners can develop the ability to self-assess and self-correct based on the feedback they have internalized.

Effective feedback should be accurate, informative, and timely. It should provide the learner with clear information on how to proceed and improve, ultimately leading to autonomous skill execution.

Types of Feedback: Intrinsic vs. Extrinsic

Intrinsic Feedback:Intrinsic feedback, also known as internal feedback, comes from the learner's own sensory systems. It is the natural information received during and after executing a motor action.

1.**Proprioceptive Feedback**: Signals from muscles, tendons, and joints provide information about body position, movement, and the forces exerted.

2.**Visual Feedback**: Information from the visual system allows learners to see the outcomes of their actions and compare them against a standard or goal.

3.**Auditory Feedback**:Sounds associated with movements, such as footfalls during running, can offer cues on rhythm, timing, and force.

4.**Tactile Feedback**:The sense of touch conveys information about grip, texture, and surface variations that can influence motor tasks

Intrinsic feedback is continuous and allows for real-time self-monitoring and adjustments to movements. As learners gain experience, their reliance on intrinsic feedback often increases, enhancing their ability to perform skills independently.

Extrinsic Feedback:Extrinsic feedback, or external feedback, is provided by sources outside the individual's sensory perception. It is crucial, especially when intrinsic feedback is insufficient

to understand the performance outcome or when the skill is too complex for the learner to self- assess accurately

1.**Knowledge of Results (KR):**Information about the outcome of the action, such as whether a basketball throw was successful.
2.**Knowledge of Performance (KP):**Information about the movement pattern used, such as the form or technique during the throw, regardless of the outcome.

3.**Augmented Feedback**:Supplemental information provided by devices or technology, such as biofeedback or motion analysis tools, that add to the intrinsic feedback.

4.**Verbal Cues**:Coach or instructor-provided guidance, corrections, and reinforcements that help shape the learning process.

Extrinsic feedback is particularly valuable in the initial stages of learning or when modifying complex or well-learned skills. It provides learners with information they cannot detect on their own and can accelerate the learning process by clarifying expectations and outcomes