The Stages of Learning

KIN 377 - Motor Learning

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Overview

Distinct performance and performer characteristics change during skill learning Magill & Anderson (2020).

Learning Objectives

- Describe characteristics of learners as they progress through the stages of learning as proposed by Fitts and Posner, Gentile, and Bernstein.
- Describe several performer- and performance-related changes that occur as a person progresses through the stages of learning a motor skill.

- Discuss several characteristics that distinguish an expert motor skill performer from a nonexpert.

Think about it

Why do people who are skilled (expert) at performing an activity often have difficulty teaching that activity to a beginner?

Think about it

To facilitate successful skill acquisition, the instructor must consider the learner's point of view and ensure that instructions, feedback, and practice conditions are in harmony with the person's needs.

- The main reason experts have difficulty teaching a domain they have mastered, is because they rarely put themselves in the learner's shoes, so to speak.

- By considering the point of view of the learner, instructors can better plan and deliver appropriate instructional strategies to ensure optimal learning.
- The content of this chapter will help you to consider the point of view of the learner.

Stages

- People progress through distinct stages (phases) as they learn a motor skill
  - Two models proposed to identify and describe the stages
    - Fitts & Posner three-stage model
    - Gentile two-stage model

In this lecture, we will study two popular models that are used to explain the stages learners go through when they learn a motor skill.

- Fitts and Posner three-stage model
- Gentile two-stage model… and yes, this is the same Gentile who developed the taxonomy we saw in chapter 1.

Example

- Here is a video that depicts the Stages of Learning as proposed by Fitts and Posner.
- Play the video and pay close attention to the different stages of learning the performer goes through before achieving optimal levels of performance.

https://youtu.be/Tva4E5g5tTo

Flashback

- Select a motor skill that you perform well, then:
  - think back to when you first learned to perform the skill
  - try to remember about the successful and not so successful moments
- How your performance changed as you became skillful?
- What characteristics of your performance changed and how did they change?

Please write your answers for future reference.

Motor learning happens in stages

- Three-Stage Model (Fitts and Posner 1967)
  - Cognitive: Learning what to do
  - Associative: Refining the movement pattern
  - Autonomous: Developing the skill
- Two-Stage Model (Gentile 1987)
  - Early stage: Getting the idea of the movement (Equivalent to Fitts & Posner Stage 1)
  - Late stage: Fixation/ diversification (Equivalent to Fitts & Posner Stage 2 & 3)

Fitts & Posner 3 Stages

Cognitive Stage

What does a performance look like?

https://youtube.com/clip/UgkxKs9F0xEcNz3jonmtQ8TeBJhZ_7Xt_3oZ?si=h3o7HLsv2fQ6GKVq

- Beginner focuses on solving cognitively-oriented problems
  - For example: How far should I move my left arm?
- Some performance characteristics:
  - Numerous errors (tend to be major errors)
  - Lack of consistency from one attempt to another
  - I know I did wrong, but how can I fix it?
- Performer's activity (behavior)
  - Learner is "getting the idea of the task" - developing a cognitive map
  - Changes performance to successively approximate task
  - Visual feedback is most important
- Performer's learning focus
  - Learning what to do

Cognitive Stage: Tips for instructors

Achieving the action goal

- When working with people who are at the initial stage of learning (Fitts & Posner or Gentile's)
  - Emphasis of instruction: should be on achieving the action goal
  - Allow learners the opportunity to explore various movement options to determine which movement characteristics provide them the greatest likelihood of success.

Making mistakes

- Expect beginners to make many movement errors and be inconsistent in how they perform the skill from one attempt to another (Magill & Anderson, 2020).
- After beginners have demonstrated that they can perform a skill with some degree of success, the emphasis of instruction should be on refining the skill and performing it more efficiently (Magill & Anderson, 2020).

- When comes to instruction, the main goal is for the learner to achieve the action goal.
- The action goal is the act of successfully perform the motor skill at hand.
- One example is to perform the forehand in tennis, and get the tennis ball over the net, and within the boundaries of the court.
- At this stage, less emphasis should be given to precision or speed. These features of the performance will be relevant later in the learning process.
- Rather, the learner should be given the opportunity to experience a variety of movements that will lead to the achievement of the action goal.
- Being inconsistent during the first stage of learning is very common, and beneficial for learning.
- The learners should be continually reminded of this to avoid loss of interest during the practice sessions.

Associative Stage

What does the performance look like/

https://youtube.com/clip/Ugkx4n7631_pz0zi2-dmZYuCwqcR5edFuWu9?si=lkG2bSdK-DI4tkkY

- Person has learned to associate environmental information with required movements:
  - Works to refine performance to be more consistent
  - Attempts to associate environmental cues with requirements of the skills
  - Fewer errors (less significant errors)

- Considered the refining stage:
  - Performance variability decreases
  - Ability to identify own performance errors
- Performer Activities (behavior)
  - `Spatial and temporal` aspects of movement are `becoming better organized`
  - `Extraneous` movement errors `decrease`
  - Dependence on visual feedback `decreases`
  - Dependence on proprioceptive feedback `increases`
  - Cognitive monitoring `decreases`
- Performer's learning focus
  - `Refining` the movement pattern
  - The goal of this phase is to `improve the organization` of the motor program

Autonomous Stage

What does the performance look like?

https://youtube.com/clip/UgkxPcSGbPoJKMMZ3hwXwwPhDi1XmP88X8rP?si=W2gbrQ_wIbYuFNlm

- Final stage where performance of the skill is "automatic" (in terms of attention demanded)
  - Performance occurs without conscious thought
  - Performance variability is very small
  - Performer can detect errors and knows how to correct them
- Performer Activities (behavior)
  - Practice task in different performance environments
  - Spatial and temporal components become highly organized
  - Movement becomes increasingly autonomous requiring little cognitive control
- Performer's learning focus
  - Developing skill (Consistent goal attainment)

Autonomous Stage: Tips for instructors

- Expect beginners to show large amounts of improvement relatively quickly, but lesser amounts of improvement as more skill is developed.

- It may be necessary to remind learners of this characteristic to motivate them to continue to practice when they experience less improvement than previously.

Scenario

Sunny is improving his time fairly quickly during the 100-meter hurdle practice sessions. This is because there are lots of room for improvement at the beginning. As Sunny gets more skilled and faster, the improvement rate will decrease. He might improve from 25 seconds to 18 seconds in the first 2 weeks of practice. But then it might take, 4 to 6 weeks for Sunny to improve from, 18 to 16 seconds.

- Not everyone will reach the autonomous stage
  - Quality of instruction and practice time is critical
- How long will it take? It depends…
- There are no abrupt changes moving through the stages
- It is difficult to detect the stage you are in
  - To help, we can try to look at the distinct characteristics between beginners and skilled performers

Gentile's Two-Stage

Initial stage: Getting the idea of the movement

Learner works to achieve two goals:

Goal 1: Acquire a `movement pattern` to enable some degree of success achieving action goal (i.e., grab a cup from the kitchen cabinet)

- Match the regulatory conditions of the environment (i.e., size of the cup, position of the cup) with WHAT is required to accomplish the task[1]

Goal 2: Learner is attempting to `discriminate between regulatory and non regulatory conditions in the environmental context` (refer to chapter 1 for the definition of regulatory and non-regulatory conditions)

- NRC: have no influence or only an indirect influence on the movement characteristics required to achieve the action goal

[1]Grasp: the learner progress trying to develop the hand and arm movement characteristics to grab the cup

Initial stage: Getting the idea of the movement

How to achieve these two goals?

- Trial and error: experiences movement characteristics that match and do not match the requirements of the regulatory conditions
- Engages in cognitive problem-solving activity
- At the end of the stage the learner:
  - has developed a movement pattern that allows some action goal achievement, but this achievement is neither consistent nor efficient

One might ask. How can I help the learner to achieve these two goals?

- You can provide lots of opportunities so that the learner can experience movement characteristics that match and do not match the requirements of the regulatory conditions.
- Note that you should design teaching strategies that allow the learner to engage in cognitive problem-solving activities. We will be studying some of these strategies along the way.
- Here's an example. Say you are teaching beginners how to perform the serve in tennis. After a couple of days of practice, the learners can serve over the net, but they are very inconsistent in getting the tennis ball to land on the designed area.

Later Stages

- Possibility of more than one stage

Involves the learner acquiring three characteristics:

- Adapting movement pattern to demands of any performance situation
- Increase consistency of action goal achievement
- Perform with an economy of effort

Learner's specific goals depend on the type of skill being learned:

`Closed skills`: fixation of movement pattern

- Develop optimal movement pattern to allow consistent action goal achievement
  - … needs to "fixate" the required movement coordination pattern to perform it consistently

`Open skills`: diversification of movement pattern

- Develop flexible movement pattern that can adapt to changing and novel environmental context conditions
- There is an unique feature in Gentile's later stages of learning:
  - The learner's specific goals depend on the type of skill being learned.
  - For example:
    - If the goal is to learn a `closed skill` (basketball free-throw shooting, for instance), then the emphasis should be on fixation.
    - If the goal is to learn a 'open skill', the learner is required to quickly adapt to the continuous changing spatial and temporal regulatory conditions of the skill.
      - must be attuned to adapt to constantly changing demands, which happen unpredictably.
- Recall that learners in this stage are striving for consistency. Thus, it makes sense that the learners need to fixate the required movement coordination pattern to perform it consistently.

Later Stages

Open vs Closed skills

- Here's a hint for instructors. When teaching closed motor skills for individuals at this stage, give emphasis to consistency. If the skill is open, on the other hand, give emphasis to diversification.
- So, give emphasis to consistency when teaching free-throw shooting, but emphasize diversification when teaching jump shooting in basketball. The former is a closed skill, while the latter is considered an open skill.
- Think about this. A jump shot in basketball can occur from anywhere inside the court; not from a single spot. Therefore, learners must experience this during practice. This is called diversification.

Stages: take home message

- Motor learning probably occurs in stages
- Activity (behavior) of the learner is different in the different stages, so…
- Instructional practices should be different in the different stages

Bernstein

Bernstein's Description of the Learning Process

- Proposed that learning a skill was similar to solving a problem
- Compared skill acquisition to staging a play, with many phases
- Described appropriate practice as a form of repetition without repetition

> Bernstein's ideas: "The point is that during a correctly organized exercise, a student is repeating many times, not the means for solving a given motor problem, but the process of its solution, the changing and improving of the means." (Bernstein, 1996, page 284).

Performer and Performance Changes Across the Stages of Learning

Performance characteristics

- Stages of learning models describe distinct performer and performance characteristics at each learning stage.
- Benefits of considering these characteristics:
  - Provides a closer look at the skill learning process.
  - Explains why different instruction strategies are needed for people in different learning stages.

Power law of practice

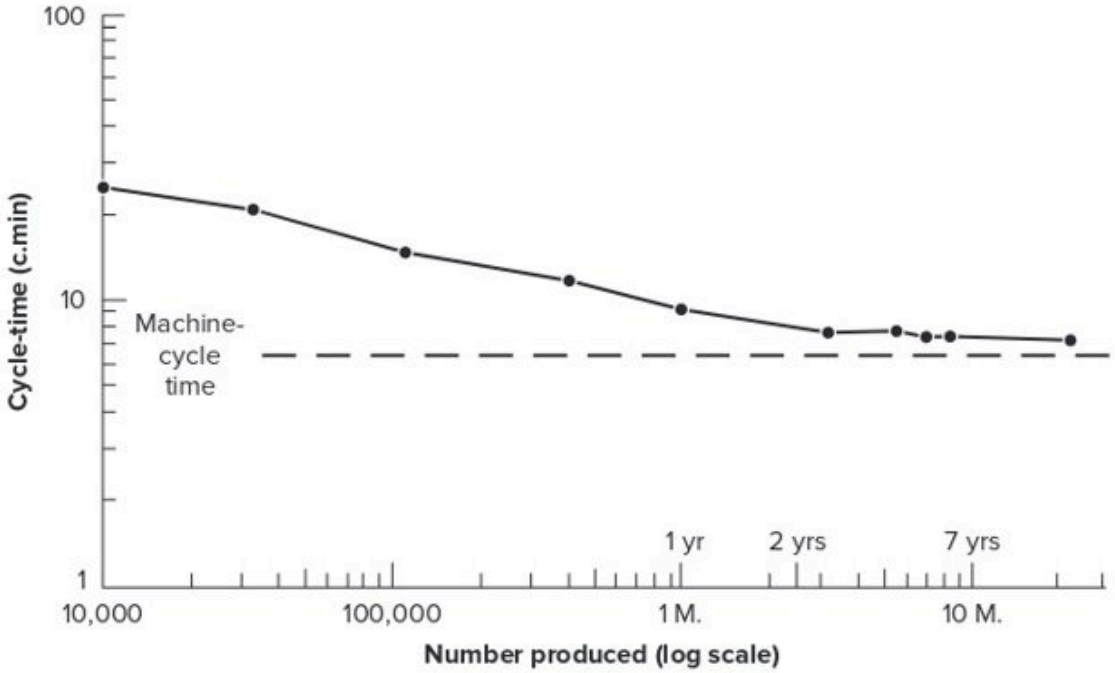


FIGURE 12.2 The results from the study by Crossman showing the amount of time workers took to make a cigar as a function of the number of cigars made across seven years of experience. Note that both axes are log scales. *Source:* From Crossman, E. R. F. W. (1959). A theory of the acquisition of speed skill. *Ergonomics, 2,* 153–166.

… a mathematical law describing the negatively accelerating change in rate of performance improvement during skill learning; large amounts of improvement occur during early practice, but smaller improvement rates characterize further practice.

Changes in movement coordination

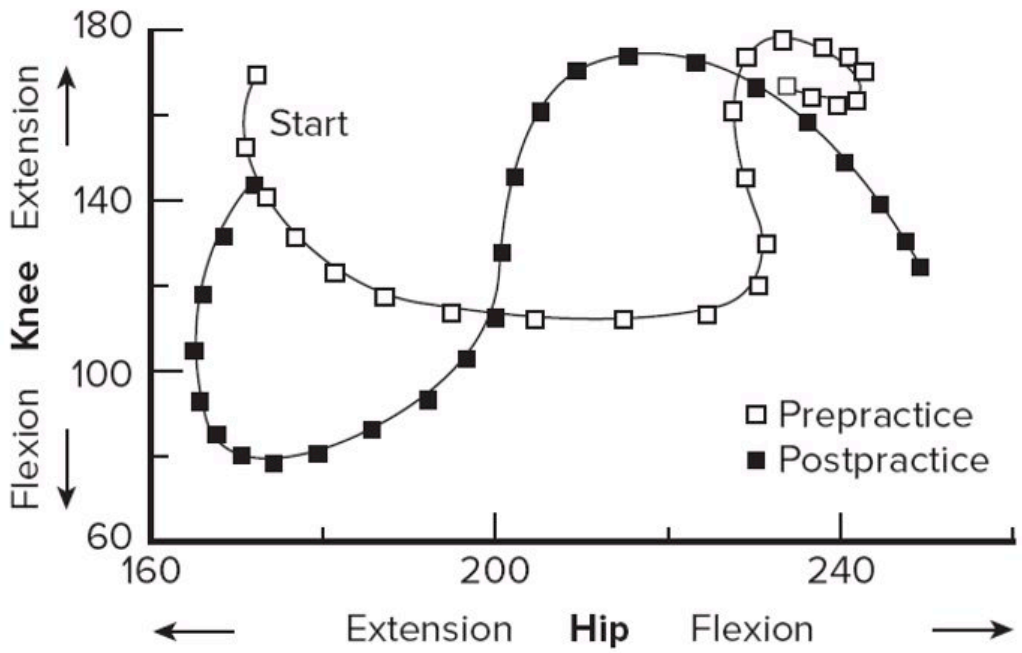
- Freezing the degrees of freedom
- Freeing of the degrees of freedom

  `Freezing the degrees of freedom`: common initial strategy of beginning learners to control the many degrees of freedom associated with the coordination demands of a motor skill; the person holds some joints rigid (i.e., "freezes" them) and/or couples joint motions together in tight synchrony while performing the skill (Magill & Anderson, 2020).

With continued practice, the learner ultimately develops a coordination pattern that is dynamically stable and more economical. Economy increases because the coordination pattern now exploits pas-osive forces, like gravity, inertia, and reactive forces, to meet the task demands. Consequently, the contribution of active muscular forces is diminished (Magill & Anderson, 2020).

Study 1

Figure 5.2: Coordination Changes Soccer Kick

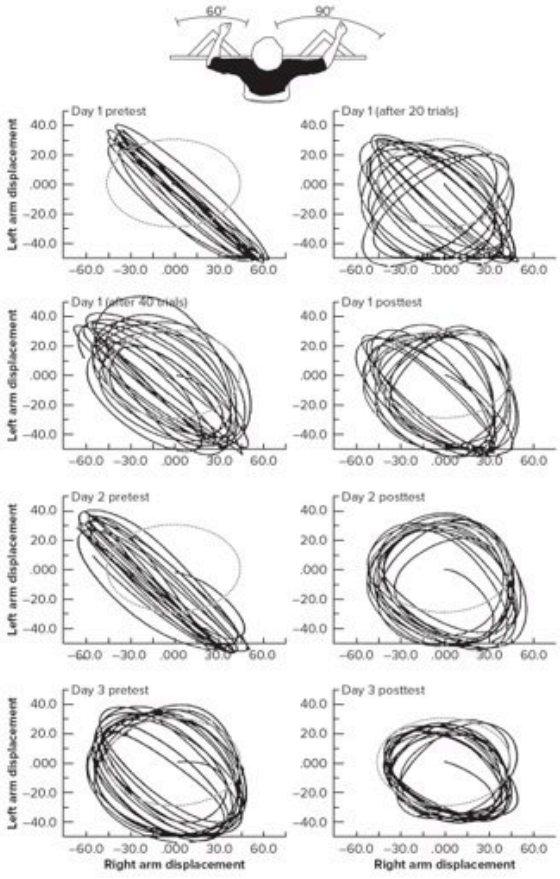


Source: From *Research Quarterly for Exercise and Sport*, Vol. 65, pp. 93 to 99, 1994 American Association for Health, Physical Education, Recreation, and Dance, 1900 Association Drive, Reston, VA 20191.

Study 2

Figure 11.4: The task and results from the experiment by Lee, Swinnen, and Verschueren.

Source: From Lee, T. D., et al. (1995). Relative phase alterations during bimanual skill acquisition. *Journal of Motor Behavior, 27,* 263 to 274.



Other changes

- Changes in muscles used to perform the skill.
- Changes in energy cost.
- Changes in visual selective attention.
- Changes in conscious attention demands when performing a skill.
- Changes in error detection and correction capability.
- Changes in brain activity: Plasticity.

A Performer Characteristic that Does Not Change Across the Stages of Learning

Learning is specific to the sources of sensory information available during practice.

- When `visual feedback` is used during practice in the first stage of learning, it continues to be needed throughout the later stages of learning.

Proteau and colleagues[2] hypothesized and provided `evidence that a dependency on the sensory feedback develops` because it becomes part of an integrated sensory component of the memory representation of the skill.

- Result: If a person must perform without the same sensory feedback available, retrieval of the representation from memory is less than optimal.

Expertise

When comes to motor skill acquisition, the term, expertise, is associated with the later stages of learning.

How is an expert?

A person who is located at the extreme right end of the learning stages continuum.

Experts in all skill performance areas have in common some distinct characteristics:

- Amount and type of practice that resulted in expertise.
- Knowledge structure.
- Use of vision.

Common characteristics

Amount and type of practice that resulted in expertise

- Intensive practice for a minimum of 10 years
- Deliberate practice: "individualized training activities specially designed to improve specific aspects of an individual's performance through repetition and successive refinement"
- Expertise is domain specific
- An expert tennis player will unlikely be (at the same time) an expert basketball player. Some characteristics might transfer from one sport to another, but expertise is acquired after many years of deliberate practice.

[2] as cited in Magill & Anderson (2020).

Common characteristics

Knowledge structure (KS)

- Declarative: knowing the rules of basketball
- Procedural: Knowing how to apply these rules in game situations
- Knowledge structure: more decision rules – if-then statements (i.e., Tennis)
- KS enable an expert to solve problems and make decisions faster and more accurately than a non-expert and to adapt to novel environments more easily.

- The second common characteristic seeing in experts is the organization of their knowledge, or knowledge structure.
- Experts have a more elaborate declarative knowledge. For example, they know a great deal of the rules pertaining to the activity they are engaged.
- They also have an extensive and well organized procedural knowledge. They not only know the rules of the activity, for example; but they also know how to apply the rules in many situations; for instance, during a game situation in the case of sport skills.
- In terms of knowledge structure, they appear to have an extensive library of (if, then) statements. For example, we typically compare experts and non experts when conducting research in this area. If a researcher asks a expert tennis player to describe the details of returning a tennis serve, she would provide many (if, then) statements. For example, the player would say: if the server does, X, then the serve is flat. If the server does ,Y, then the serve is topspin. If the server does, Z, then the serve is a slice. The expert associate well X, Y, Z with the actions to take in order to predict where the tennis ball will hit his/her side of the court. The non expert is often unable to do it.

Common characteristics

Use of vision

- Experts use vision in more advantageous ways than novices do
- Search their environment faster
- Give more attention to this search
- Select more meaningful information in less time
- Use vision to anticipate the actions of others

- And finally, the third common characteristic shared my experts is the use of vision.
- Experts are really good at searching their environment faster than non experts.
- They tend to select more meaningful information in less time, which gives them the edge in many situations.
- Experts also take advantage of the fast visual search strategies to anticipate movement actions and predict movement actions.

Is Expert Performance Automated?

Ericsson argues that it is not fully automated.

- Experts attempt to avoid the stagnation that comes with complete automaticity.
- They need some control to make improvements and adapt to new situations.
- Expertise in a wide range of domains is mediated by increasingly complex cognitive control processes - think aloud protocols.
- Experts recycle through the stages of learning though in a more sophisticated way than novices.

The bottom line

- Prioritize instructional efforts for early knowledge acquisition by allowing novices to explore various movement options to determine the most effective features for success.
- Expect beginners to make many movement errors and be inconsistent in performing the skill from one attempt to another.
- The instruction should focus on enhancing the skill and performing it more effectively after beginners have shown they can do it with some success.
- Instruction for closed and open skills should be similar for novice learners, emphasizing successful movement qualities, repetition in environmental contexts and successful adaptation to regulatory conditions. After a level of success, the emphasis for closed skills should be on fixation of the selected successful movement patter, whereas for open skills the emphasis should be on diversification.
- Novices may show rapid improvement, but progress slows as skill level increases. Emphasizing persistence is crucial to encourage progress, especially when faced with less progress.
- New to a skill, individuals may initially use similar movement tactics to their previous skills, but over time, these tactics may hinder their success and become an expert.

References

Magill, R. A., & Anderson, D. (2020). *Motor learning and control: concepts and applications*. McGraw-Hill Education. https://www.bkstr.com/csunorthridgestore/product/motor-learning-and-control--concepts-and-applications-147614-1