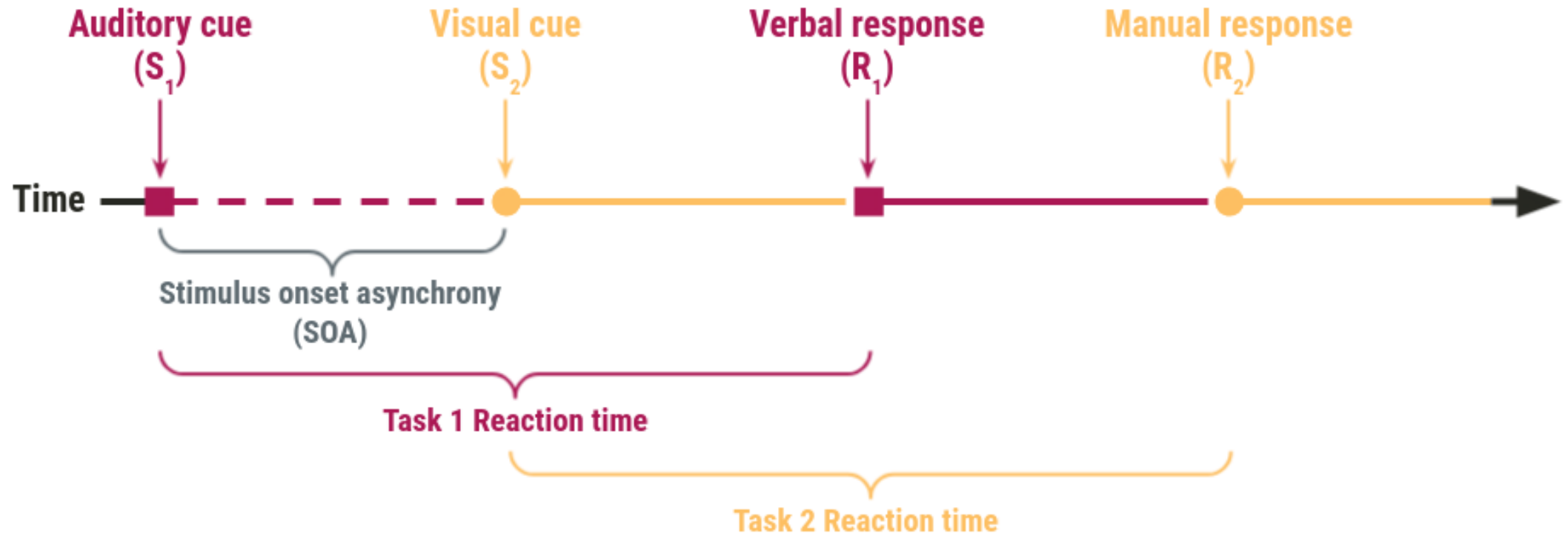# Motor learning: Fundamentals

KINESIOL 1E03 - Motor control and learning

Laura St. Germain
Fall 2021 Week 6
Lecture 12

Review from last lecture

The time between the presentation of two stimuli can have a strong influence on performance
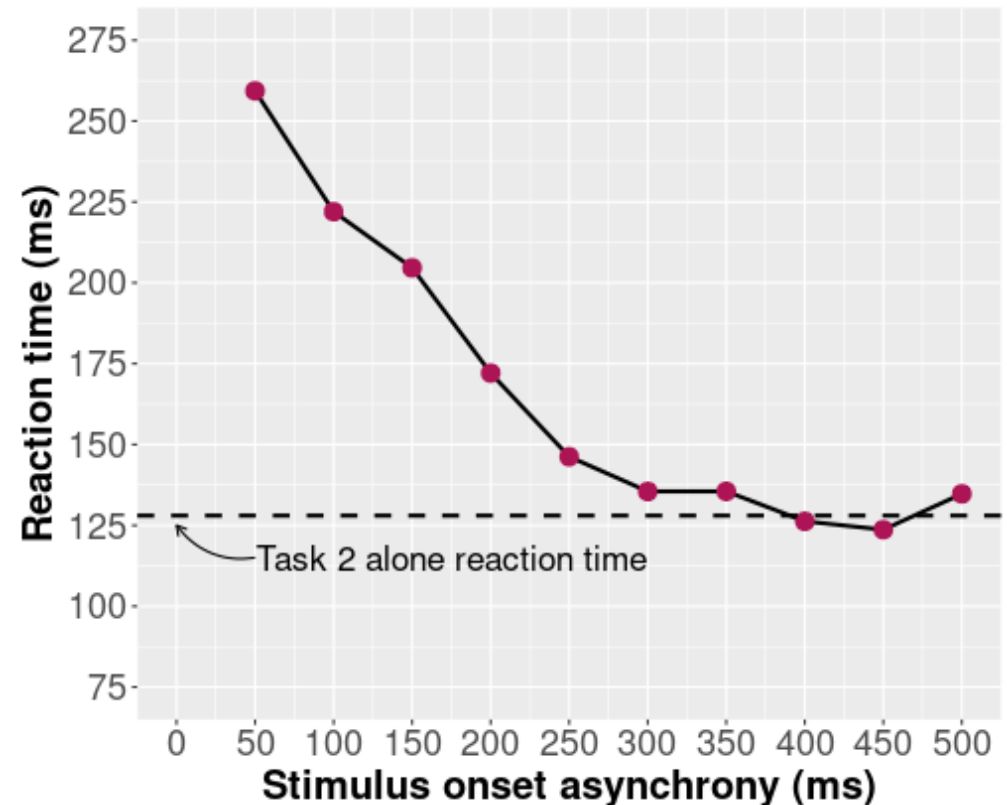
Psychological refractory period (PRP) decreases as SOA increases

Task 1 reaction time: 161 ms

Task 2 (control) reaction time: 128 ms

*We need to **compare** the reaction times of **Task 2 in the sequential condition** (Task 1 then Task 2) to the **Task 2 alone** (i.e., control condition) to determine whether a **PRP** happened*
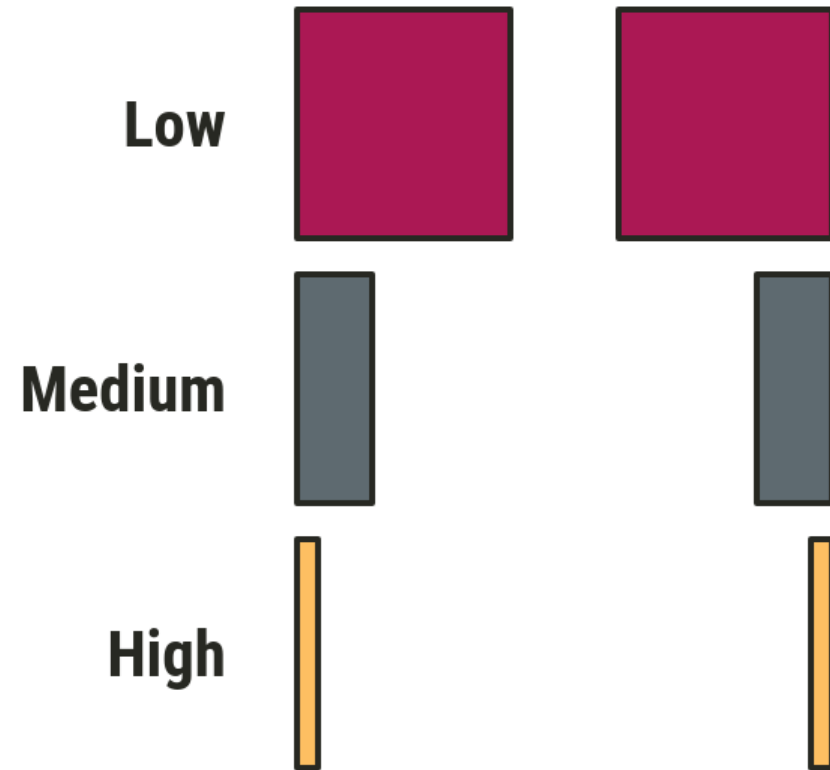

Approximate data of Davis 1959 through plot digitization of adapted figure in Schmidt & Lee 2011

We can manipulate task difficulty with changes in width and/or amplitude
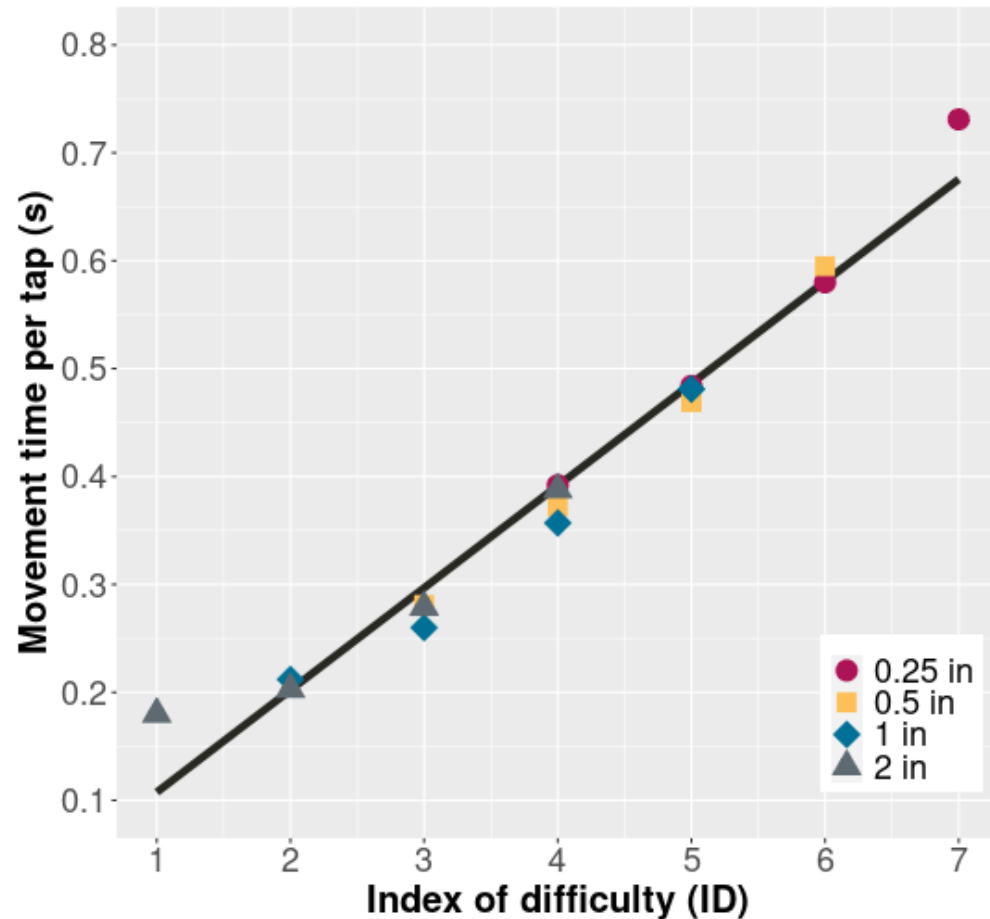
$$MT = a + b \log_2(2A/W)$$

where:

- *a* = y-intercept
- *b* = slope
- *A* = amplitude
- *W* = width
- *log$_2$(2A/W)* = **index of difficulty**

Q: What does this remind you of?

ID determines movement time per tap

- Movement **time per tap increases** as movement **amplitude increases**

- Movement **time per tap increases** as target **width decreases**

- Movement **time per tap is constant** for a **fixed ratio** of movement **amplitude** to target **width**

- Experience an online Fitts' task: http://fww.few.vu.nl/hci/interactive/fitts/

Reciprocal tapping task data from Fitts 1954 (https://doi.org/10.1037/h0055392) 1 oz stylus condition

Any questions?

How do we go...

from this ⇓

to this ⇓

Learning objectives

1. Define **motor learning**.

2. Describe and understand the **distinction** between performance and learning.

3. Identify and explain **general characteristics** of the learning process.

4. Understand how we **measure** motor performance and motor learning.

Take-home message:

Valid conclusions about motor learning depend on reliably separating relatively permanent effects on performance from transient effects on performance.

Performance versus learning

Performance

- **Observable** behaviour
- **Temporary**
- **May not** be due to practice
- **Influenced** by performance variables

Learning

- **Inferred** from performance
- **Relatively** permanent
- **Due** to practice
- **Not influenced** by performance variables

Motor learning

Motor learning is a **set of processes** resulting from **practice or experience** causing **relatively permanent gains** in the **capability for skilled performance**.

Motor learning is an umbrella term but there are (at least) two main types

SKILL ACQUISITION: the processes by which an individual acquires the ability to identify an appropriate movement goal given a particular task context, select the correction action given a sensory stimulus and/or the current state of the body and the world, and execute that action with accuracy and precision

SKILL MAINTENANCE: the ability to maintain performance levels of existing skills under changing conditions

Motor learning is an umbrella term but there are (at least) two main types

Skill acquisition

Learning to throw

Learning to swing a bat

Once the **skill** is **acquired,** it can be **modified/adapted** to maintain performance and meet task demands
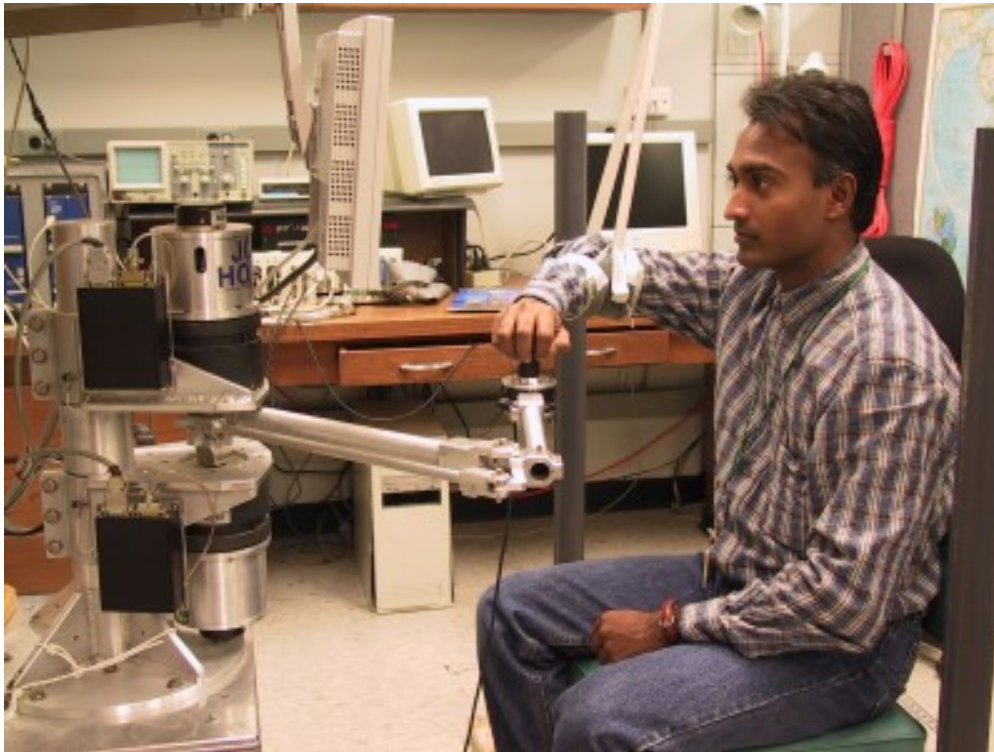
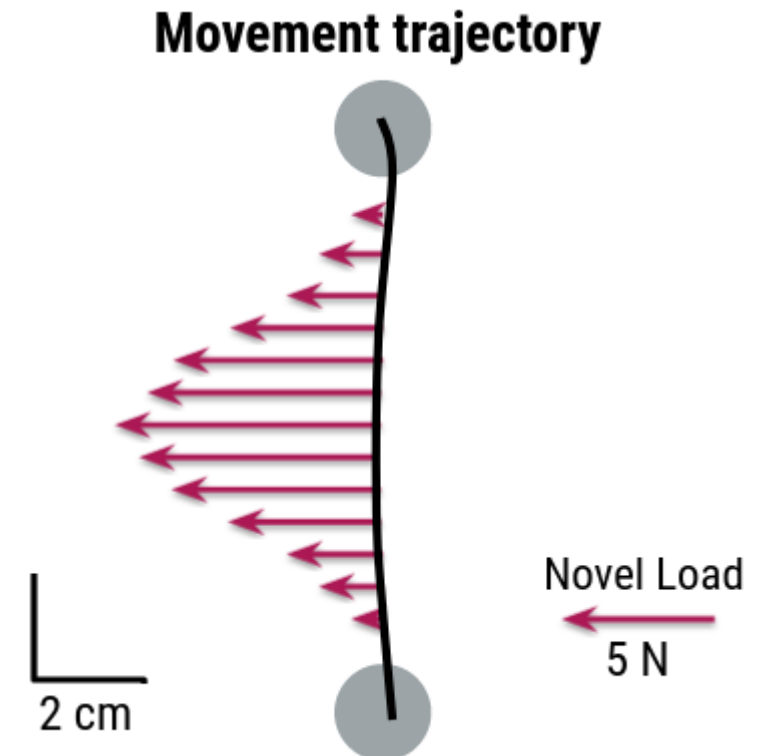This is still debated in the field.

Skill maintenance

So how can we study motor learning?

Skill maintenance

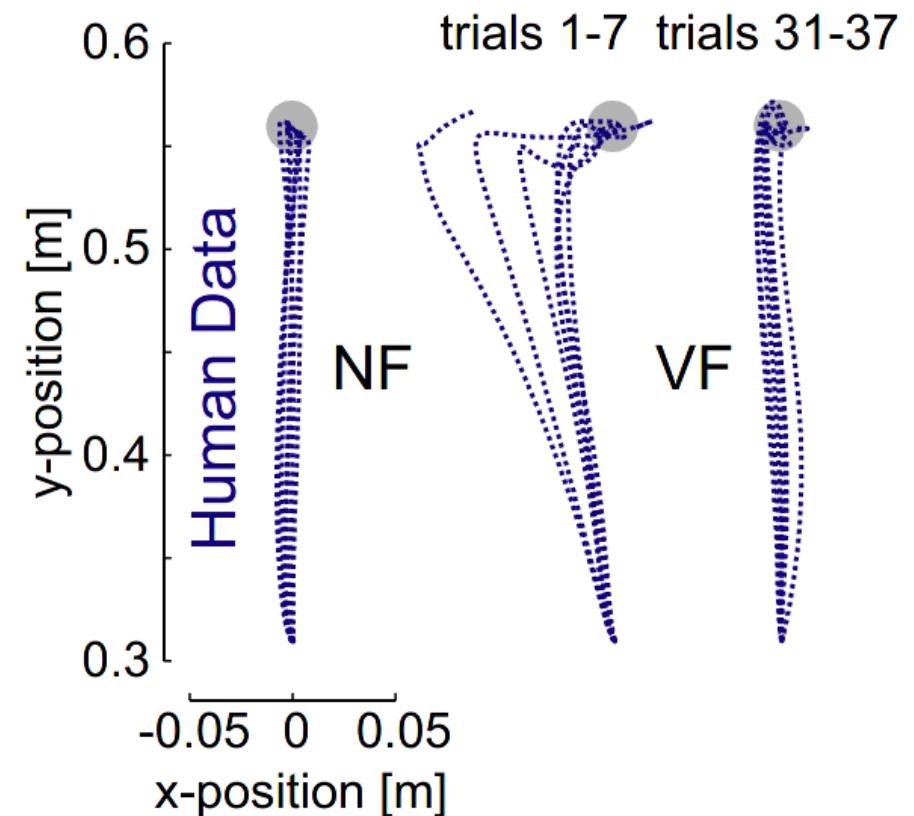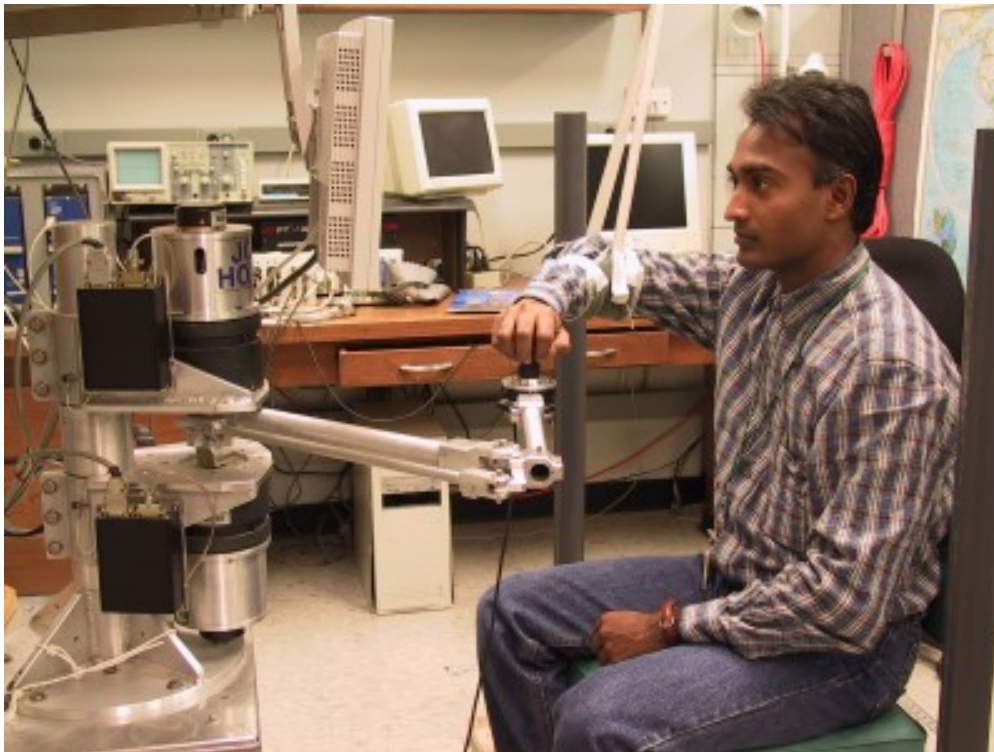An example of a skill maintenance paradigm is **force-field reaching**

Source: https://www.shadmehrlab.org/

Skill maintenance

An example of a skill maintenance paradigm is **force-field reaching**

Source: https://www.shadmehrlab.org/
Right fig: Franklin et al. 2008 (https://doi.org/10.1523/JNEUROSCI.3099-08.2008)
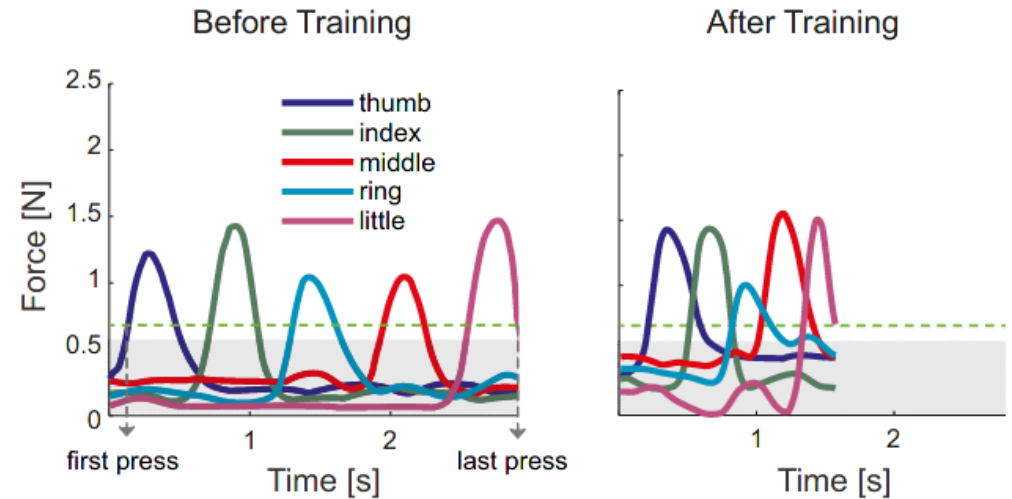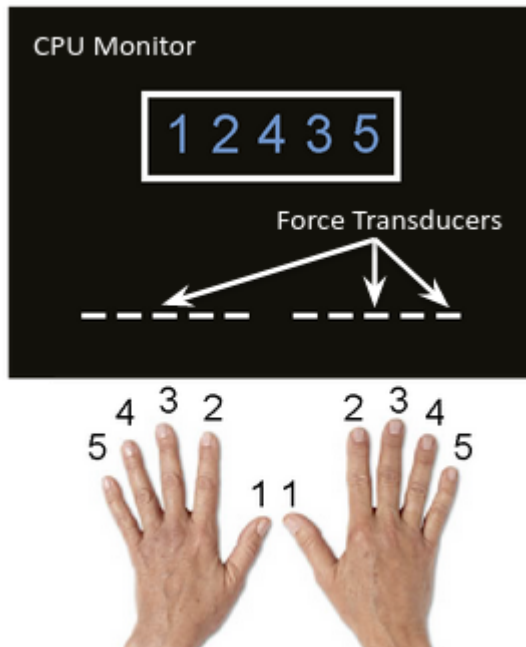
Skill acquisition

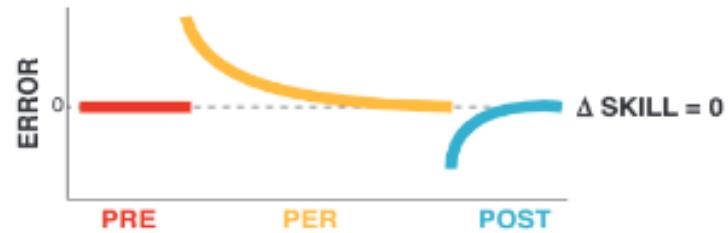An example of a skill acquisition paradigm is **sequence learning**
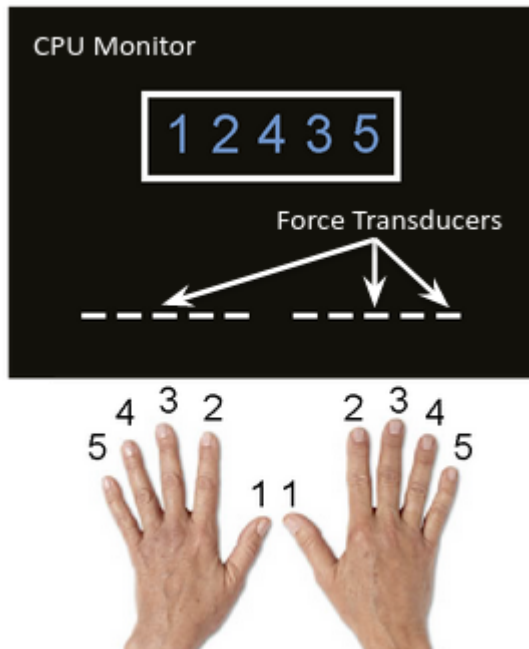
Skill acquisition

An example of a skill acquisition paradigm is **sequence learning**

Summary: Ways to study motor learning
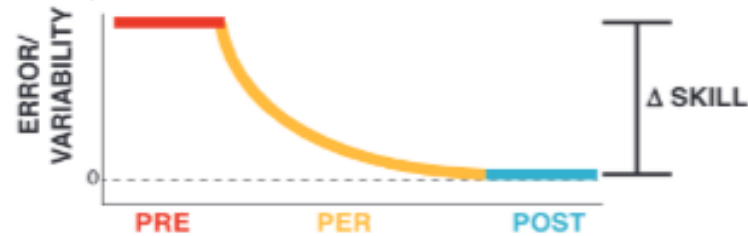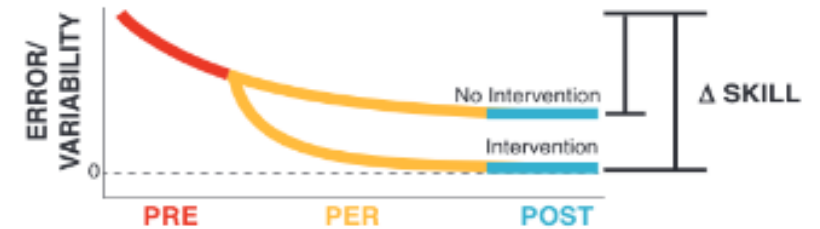

1) Skill maintenance — ERROR; PRE, PER, POST; Δ SKILL = 0

2) Skill acquisition — ERROR/VARIABILITY; PRE, PER, POST; Δ SKILL

3) Skill acquisition: Intervention — ERROR/VARIABILITY; PRE, PER, POST; No Intervention, Intervention; Δ SKILL

Practice is associated with, but does not guarantee, learning

Good learner

Poor learner

Source: https://waxgolf.files.wordpress.com/2019/06/rory-mcilroy-drive.gif

Source: https://clubhouse.swingu.com/wp-content/uploads/2020/04/charlesold.gif

# Learning produces relatively permanent changes in performance

We can observe 7 performance characteristics during the learning process

Performance characteristics of learning

1. **Improvement**: performance of the skill gets **better with time**

2. **Consistency**: performance of the skill becomes **increasingly less variable** with time

3. **Stability**: performance becomes **increasingly more resistant** to *external* and *internal* perturbations

4. **Persistence**: the **improved performance capability** increases in its persistence

5. **Adaptability**: the improved performance can **generalize** to a variety of performance context characteristics

6. **Decreased attention demand**: learner can more easily perform **concurrent** activities

7. **Decreased energy cost**: performance of the skill becomes **more efficient** with time

We can illustrate performance graphically with performance or learning curves
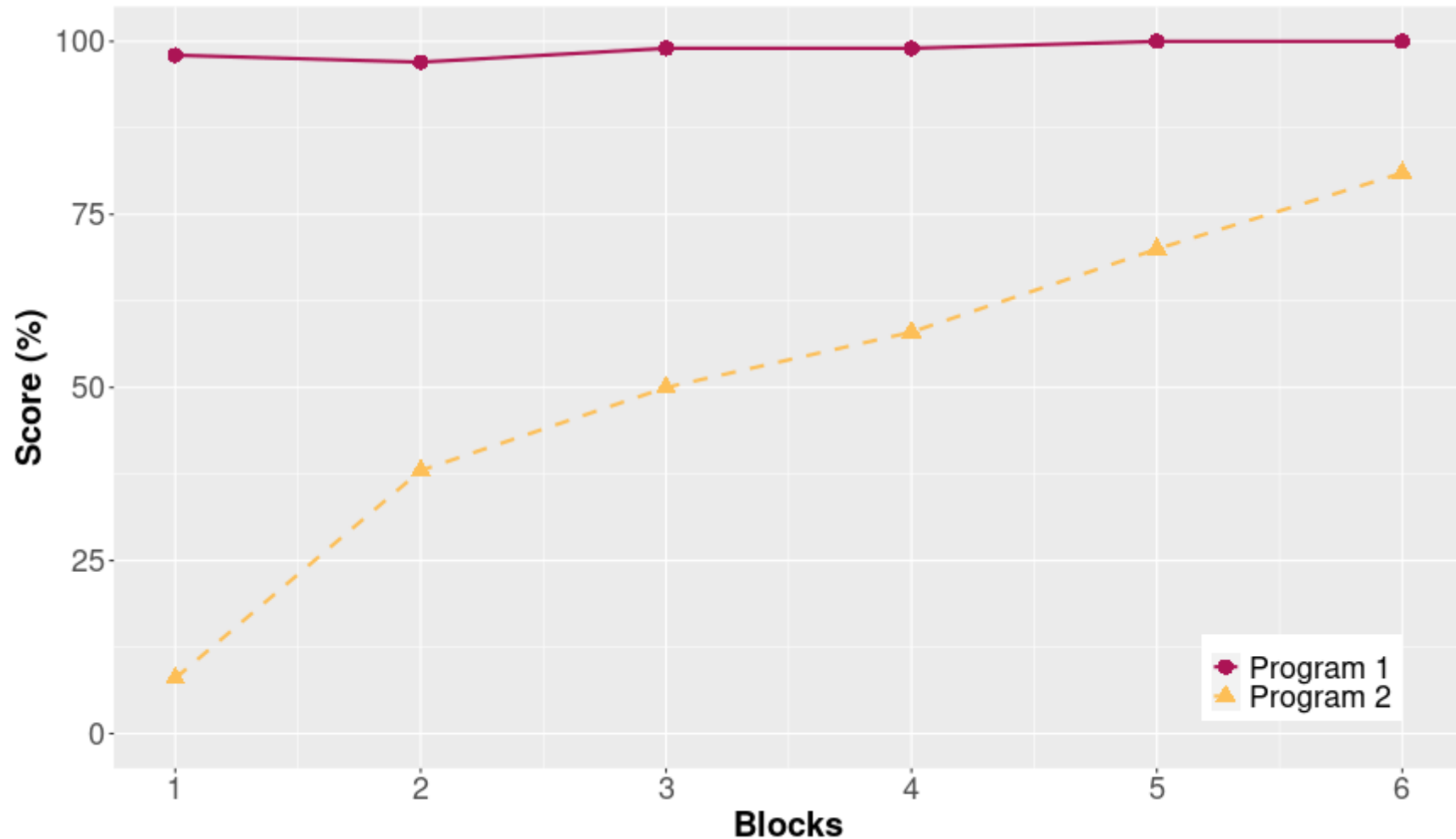
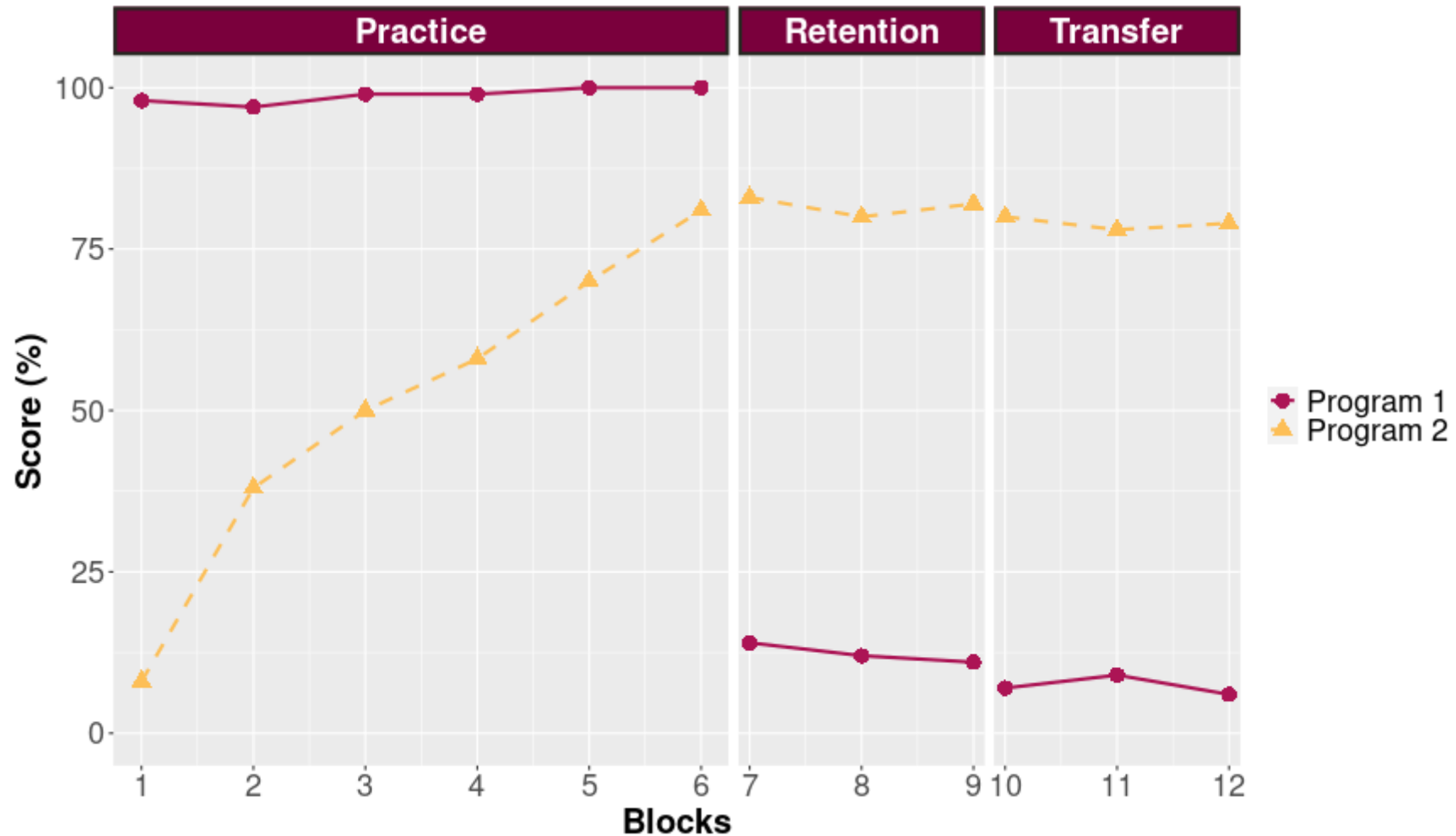- We typically report the **mean performance across trials and/or people**
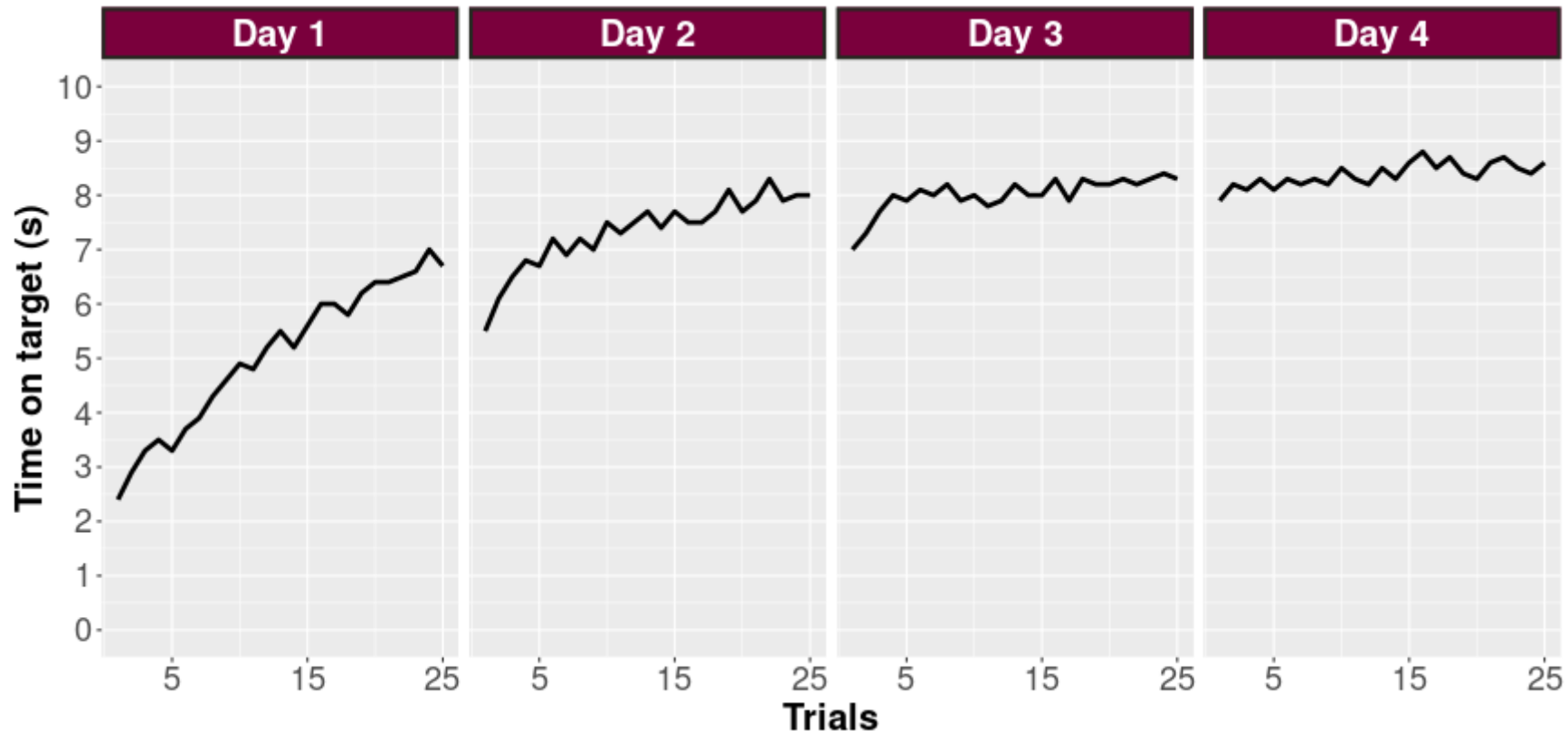
Understanding the basic mechanisms of motor control and learning is essential for teaching and rehabilitating skilled behaviours

Which training program would you recommend?

Which training program would you recommend?

We need to rely on methods that can separate the relatively permanent effects from transient ones

Performance-learning paradox

- a high level of performance in practice **does not** mean an individual has learned the task

- a low level of performance in practice **does not** mean an individual has not learned the task

- To avoid being a victim of this paradox, we must rely on performance in **retention** and **transfer** tests when making evidence-based recommendations

Knowledge translation of best practice conditions poses a considerable challenge

*Too often our **perceptions** about the **best** ways to facilitate learning are **heavily biased***

We must use retention or transfer tests to measure whether a skill has been learned

Retention tests

- Assesses the **permanence** or **persistence** of the skill

- Occurs after a period of **no practice** (rule of thumb is minimum of 24 hours)

- Are performed under a **common level** of the manipulated practice variable

- The number of tests **can vary** from experiment to experiment

Transfer tests

- Assesses the **adaptability** or **flexibility** of the skill

- Occurs after a period of **no practice** (rule of thumb is minimum of 24 hours)

- Are performed under a **common level** of the manipulated practice variable

- The number of tests **can vary** from experiment to experiment

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What questions do you have?
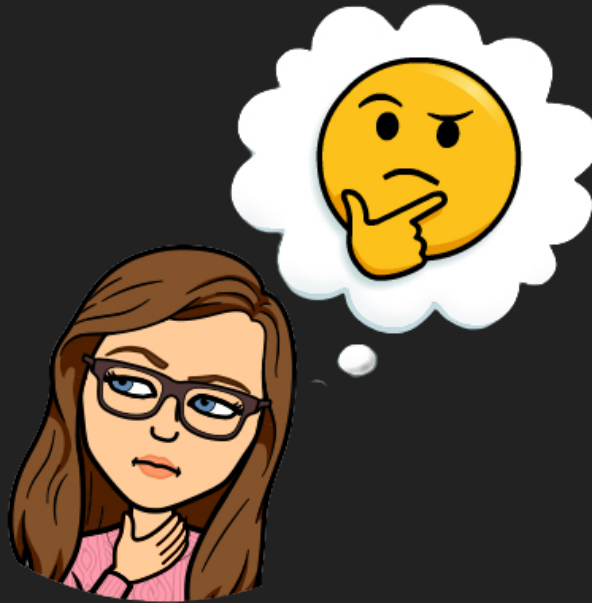
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