McMaster University

SCIENCE
Department of Kinesiology

Measurement: Error scores

KINESIOL 1E03 - Motor control and learning

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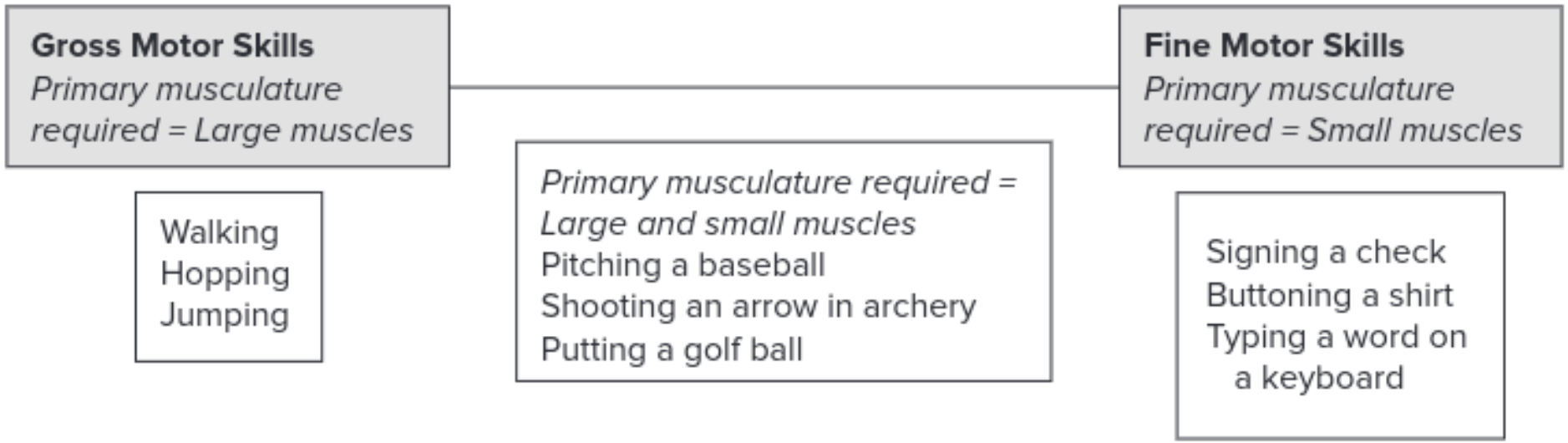
Fall 2021 Week 1
Lecture 3

Review from last lecture

1D classification systems

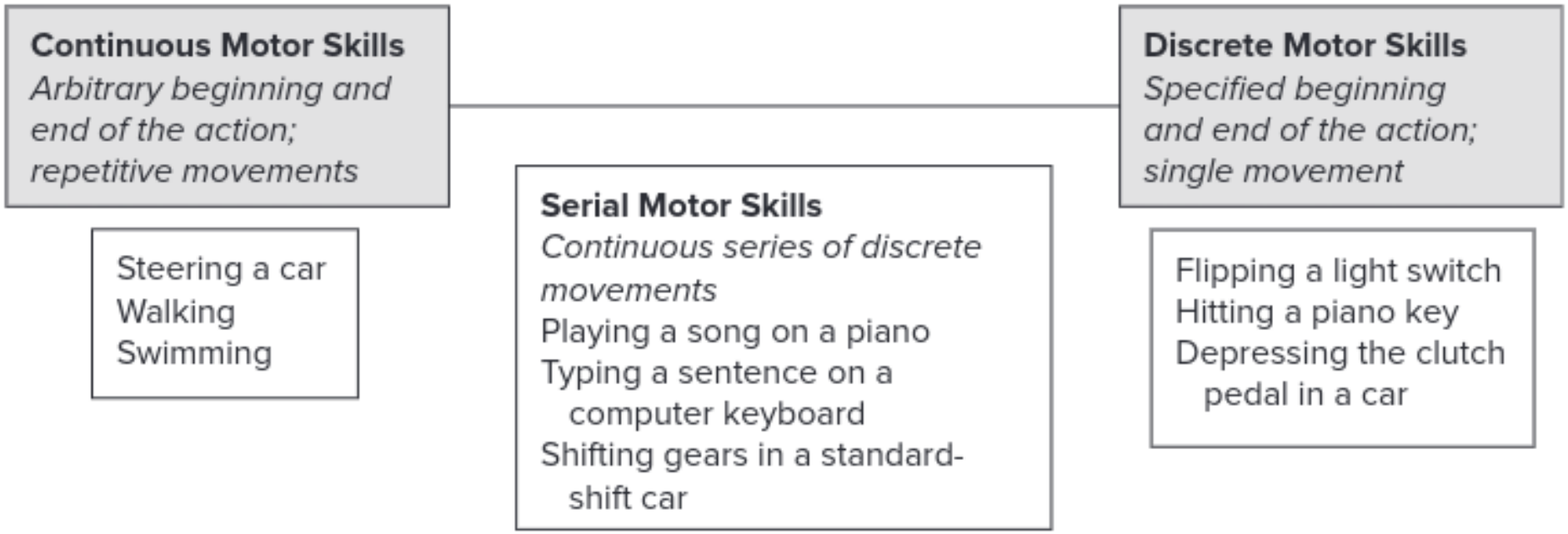
Size of primary musculature required



Magill & Anderson 2017, p. 10

1D classification systems

Specificity of where actions begin and end



Magill & Anderson 2017, p. 10

1D classification systems

Stability of the environmental context

Magill & Anderson 2017, p. 10

Gentile's two-dimensions taxonomy

	Action Function			
	Body Stability		Body Transport	
Environmental ↓ Context	**No Object Manipulation**	**Object Manipulation**	**No Object Manipulation**	**Object Manipulation**
Stationary Regulatory Conditions and No Intertrial Variability	**1A** Body stability No object Stationary regulatory conditions No intertrial variability • *Standing alone in a room* • *Holding a yoga pose*	**1B** Body stability Object Stationary regulatory conditions No intertrial variability • *Brushing teeth standing alone at a sink each day of the week* • *Shooting basketball free throws*	**1C** Body transport No object Stationary regulatory conditions No intertrial variability • *Climbing stairs* • *Running around an empty track*	**1D** Body transport Object Stationary regulatory conditions No intertrial variability • *Climbing stairs while holding a book* • *Practicing a penalty shot in soccer without a goal keeper*
Stationary Regulatory Conditions and Intertrial Variability	**2A** Body stability No object Stationary regulatory conditions Intertrial variability • *Standing on different surfaces* • *Performing handstands on different gymnastics apparatuses*	**2B** Body stability Object Stationary regulatory conditions Intertrial variability • *Washing dishes while standing at a sink* • *Putting golf balls from various locations on a putting green*	**2C** Body transport No object Stationary regulatory conditions Intertrial variability • *Walking on different surfaces* • *Agility drills through different obstacle courses*	**2D** Body transport Object Stationary regulatory conditions Intertrial variability • *Walking on different surfaces while carrying a bag of groceries* • *Pole vaulting over bars set at different heights*

Magill & Anderson 2017, p. 14

Gentile's two-dimensions taxonomy

	Action Function			
	Body Stability		Body Transport	
Environmental Context	No Object Manipulation	Object Manipulation	No Object Manipulation	Object Manipulation
In-Motion Regulatory Conditions and No Intertrial Variability	**3A** Body stability No object Regulatory conditions in motion No intertrial variability • *Walking on a treadmill at a constant speed* • *Riding a mechanical bull with consistent motion*	**3B** Body stability Object Regulatory conditions in motion No intertrial variability • *Walking on a treadmill at a constant speed while using a smartphone* • *Catching a series of softballs thrown at the same speed by a pitching machine*	**3C** Body transport No object Regulatory conditions in motion No intertrial variability • *Standing on a moving escalator at a constant speed* • *Sprinting to the top of an escalator moving in the opposite direction*	**3D** Body transport Object Regulatory conditions in motion No intertrial variability • *Standing on a moving escalator while holding a cup of water* • *Running to hit a tennis ball projected by a ball machine*
In-Motion Regulatory Conditions and Intertrial Variability	**4A** Body stability No object Regulatory conditions in motion Intertrial variability • *Walking on a treadmill at different speeds* • *Cheerleader standing on a swaying teammate's shoulders*	**4B** Body stability Object Regulatory conditions in motion Intertrial variability • *Walking on a treadmill at different speeds while reading a book* • *Catching softballs thrown at various speeds by a teammate*	**4C** Body transport No object Regulatory conditions in motion Intertrial variability • *Walking in a crowded mall* • *Avoiding being caught in a game of tag*	**4D** Body transport Object Regulatory conditions in motion Intertrial variability • *Walking in a crowded mall carrying a baby* • *Practicing several soccer plays with a ball and defenders*

Magill & Anderson 2017, p. 15

Any questions?

Learning objectives

1. Describe the differences between and give examples of **performance outcome** and **performance production** measures.

2. Describe and compute **common error score measures** for different types of motor skills.

Take-home message:

There are many ways we can measure motor performance. Often the appropriate measure depends on the individual, task/skill, and/or environment. Valid conclusions about motor behaviour depend on the use of appropriate measures.

We can broadly classify performance measures using 2 categories

PERFORMANCE OUTCOME MEASURES: measures that indicate the result of an action

- **may or may not** be relative to some **task goal**
- e.g., how fast a person ran 100 m; how far away a missed putt was from the hole

PERFORMANCE PRODUCTION MEASURES: measure that indicate how the nervous, muscular, and/or skeletal systems function during an action

- capture the **performance characteristics** that resulted in a given performance outcome
- e.g., limb kinematics; feedback-related negativity potential

Some ways to measure performance

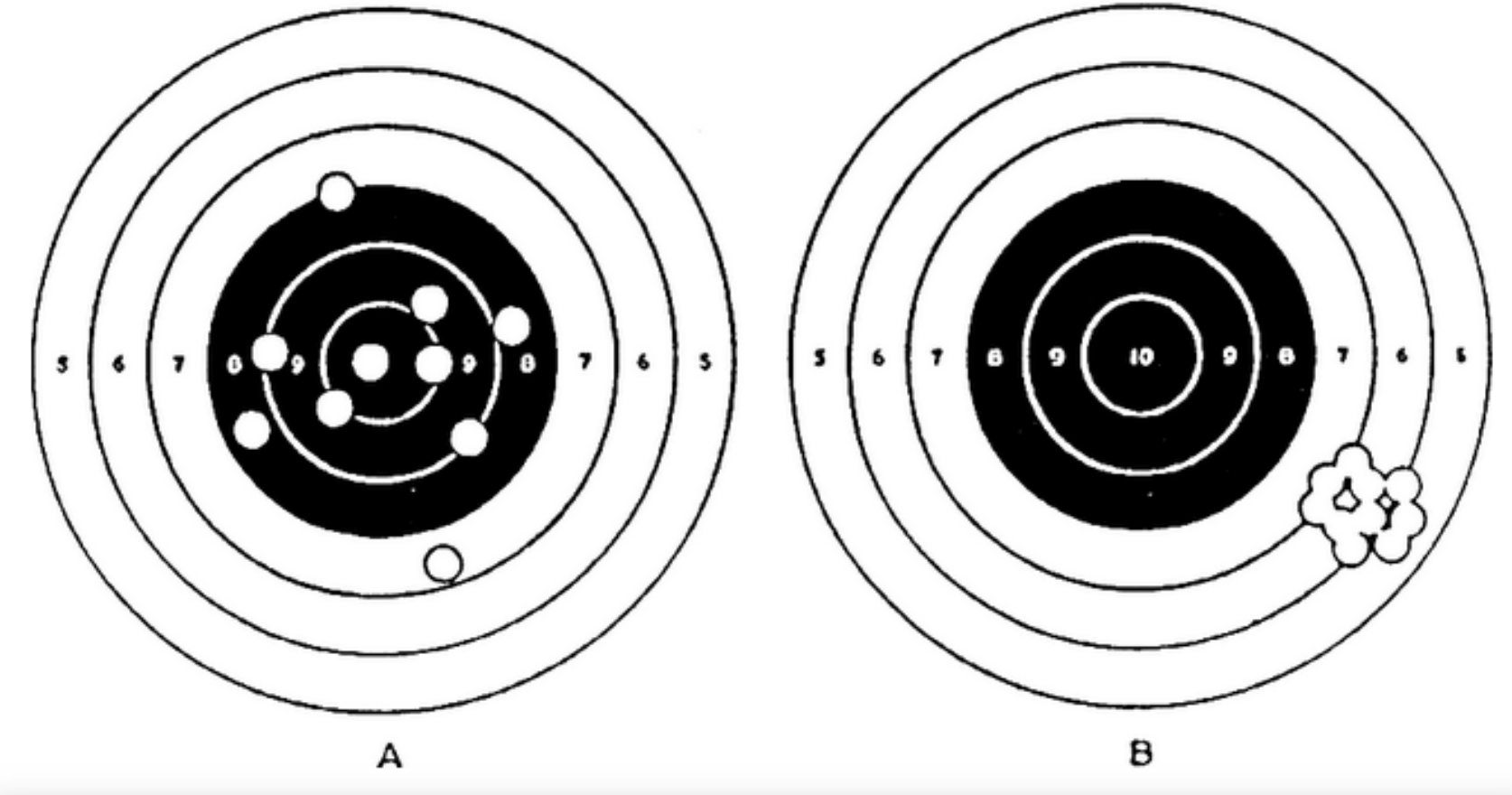
Performance outcome measures

- Time to complete a task
- Reaction time
- Amount of error in performing criterion movement
- Time on target / Time in balance
- Trials or repetitions to completion
- Number or percentage of errors
- Number of successful attempts
- etc...

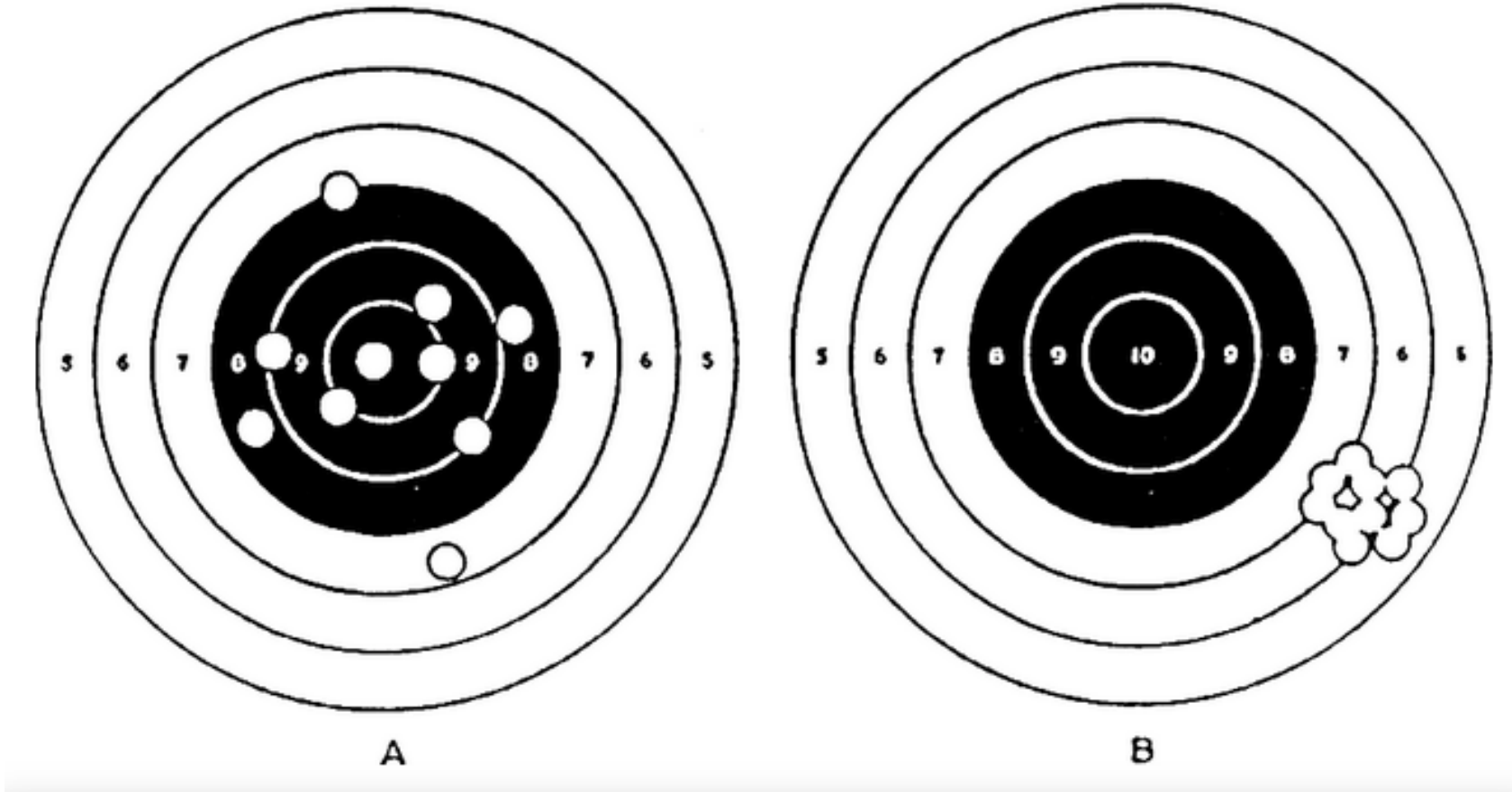
Performance production measures

- Displacement, velocity, and/or acceleration
- Joint angle and/or joint torque
- Electromyography
- Electroencephalogram
- Functional magnetic resonance imaging
- Positron emission topography
- Transcranial magnetic stimulation
- Functional near-infrared spectroscopy
- etc...

Q: Is Person A or Person B better?

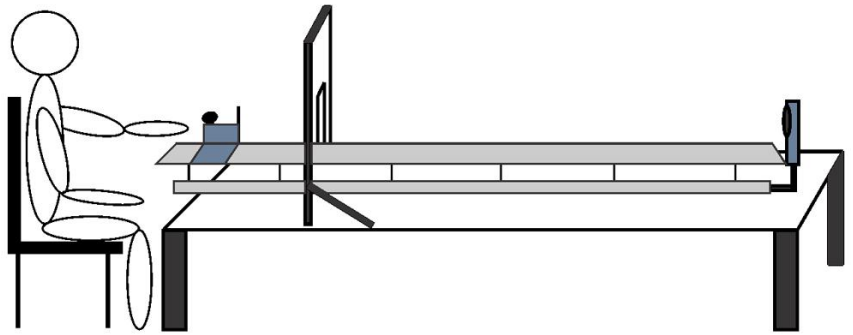


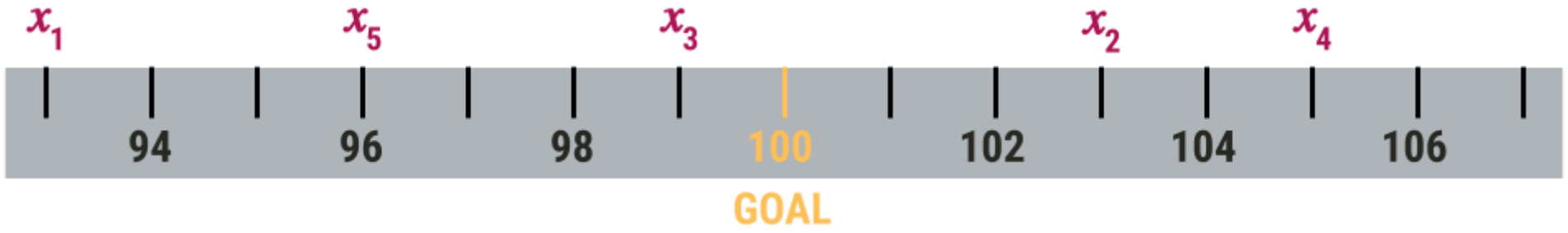
Q: Would you rather coach Person A or Person B?



Consider the following scenario

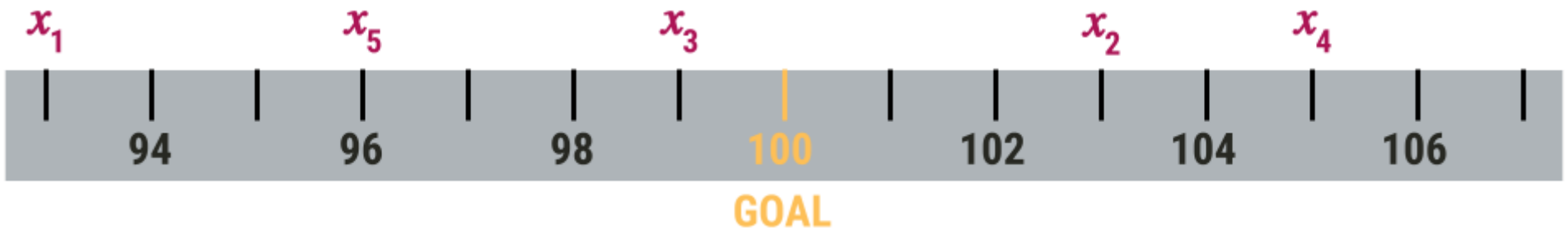
A person is tasked with learning to project a slider down a fixed track to a specified goal distance of 100 cm using their non-dominant hand. The person performs 5 trials of this task. On each trial you record the distance the slider traveled from the starting point (a wooden barrier). The result for each trial is shown below:





Q1: How should we measure performance on this task?
Q2: What type of measure would this be?
Q3: How would you classify this task?

Constant error measures the bias in responding



We can calculate using:

$$CE = x_i - T$$

$$Mean\,CE = \sum(x_i - T)/n$$

```
# Calculate CE
((93 - 100) + (103 - 100) + (99 - 100) + (105
```

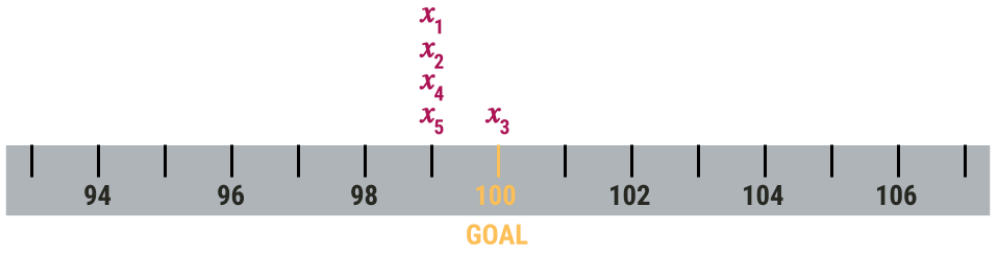
```
## [1] -0.8
```

Mean CE = -0.8 cm

How do we interpret this?

Consider the following scenario

What is the mean CE for this block of trials?

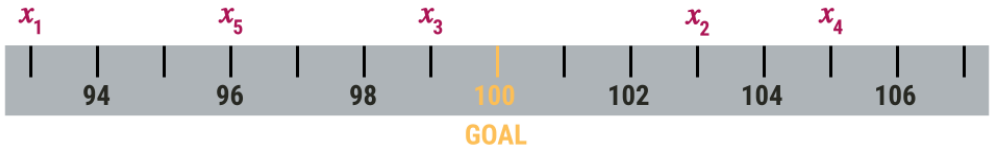



```
# Calculate CE
((99 - 100) + (99 - 100) + (100 - 100) + (99
```

```
## [1] -0.8
```

Mean CE = -0.8 cm

Here's the first block of 5 trials again...



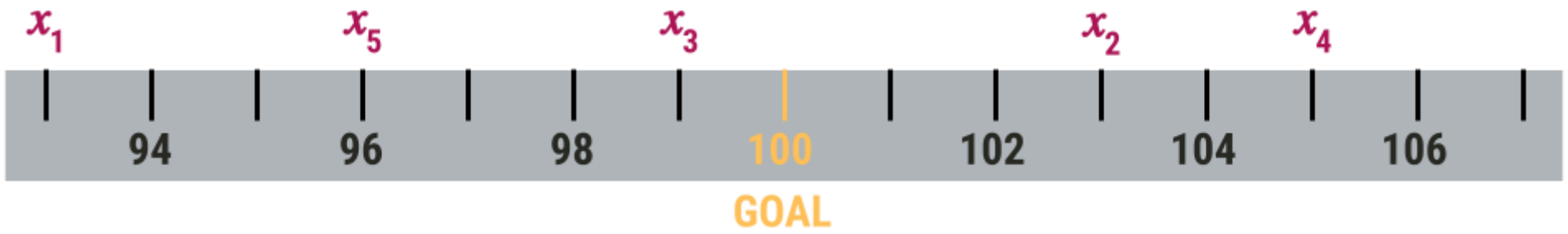

```
# Calculate CE
((93 - 100) + (103 - 100) + (99 - 100) + (105
```

```
## [1] -0.8
```

Mean CE = -0.8 cm

What do we learn from this?

Variable error measures the inconsistency in responding



We can calculate using:

$$Mean\,VE = \sqrt{\sum(x_i - M)^2/n}$$

```
# Calculate M for VE
(93 + 103 + 99 + 105 + 96) / 5
```

```
## [1] 99.2
```

```
# Calculate VE
sqrt(((93 - 99.2)^2 + (103 - 99.2)^2 + (99 -
```

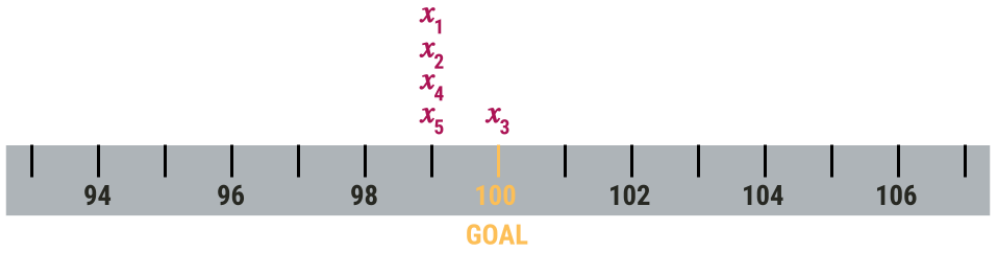
```
## [1] 4.4
```

Mean VE = 4.4 cm

How do we interpret this?

Let's return to this scenario

Second block of 5 trials...




```
# Calculate VE
sqrt(((99 - 99.2)^2 + (99 - 99.2)^2 + (100 -
```

```
## [1] 0.4
```

Mean VE = 0.4 cm

First block of 5 trials...

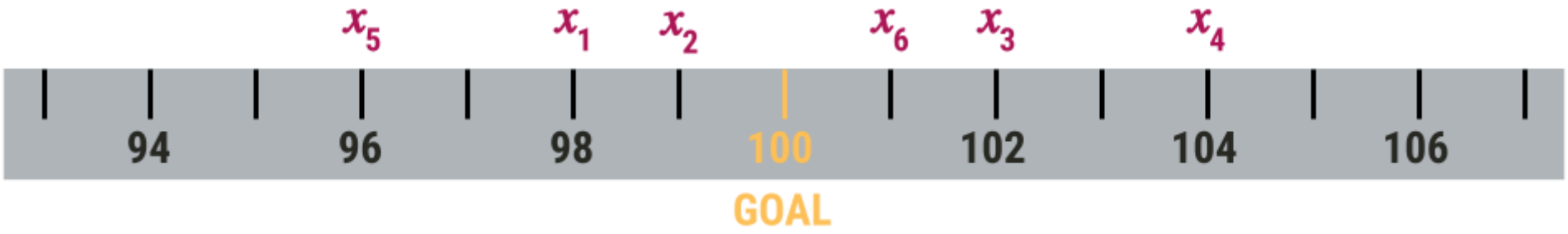

```
# Calculate VE
sqrt(((93 - 99.2)^2 + (103 - 99.2)^2 + (99 -
```

```
## [1] 4.4
```

Mean VE = 4.4 cm

What do we learn from this?

What is the mean CE for this block of 6 outcomes?



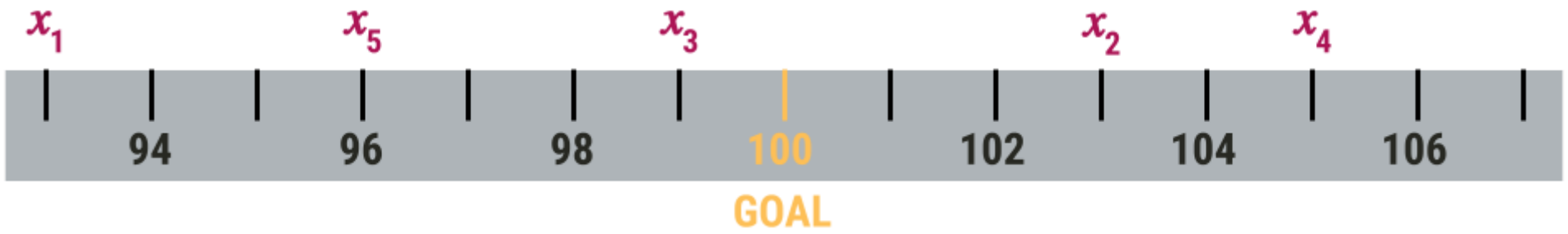
Source: https://i.gifer.com/4yu.gif

```
# Calculate CE
((98 - 100) + (99 - 100) + (102 - 100) + (104
```

```
## [1] 0
```

Mean CE = 0 cm

Absolute error measures overall accuracy in responding



We can calculate using:

$$AE = |x_i - T|$$

$$Mean\ AE = \sum |x_i - T|/n$$

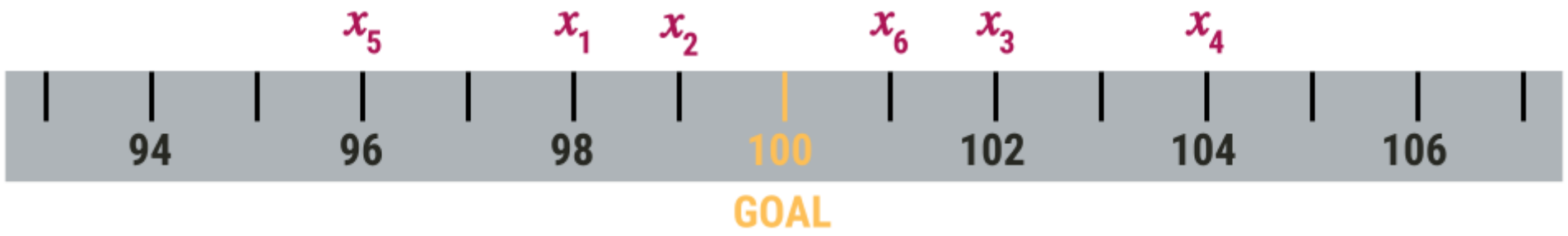
```
# Calculate AE
(abs(93 - 100) + abs(103 - 100) + abs(99 - 10
```

```
## [1] 4
```

Mean AE = 4 cm

How do we interpret this?

Let's return to this 6 trial block




```
# Calculate CE
((98 - 100) + (99 - 100) + (102 - 100) + (104 - 100) + (96 - 100) + (101 - 100)) / 6
```

```
## [1] 0
```

```
# Calculate AE
round((abs(98 - 100) + abs(99 - 100) + abs(102 - 100) + abs(104 - 100) + abs(96 - 100) + abs(10
```

```
## [1] 2.3
```

What do we learn from this?

What is the relationship among CE, VE, and AE?

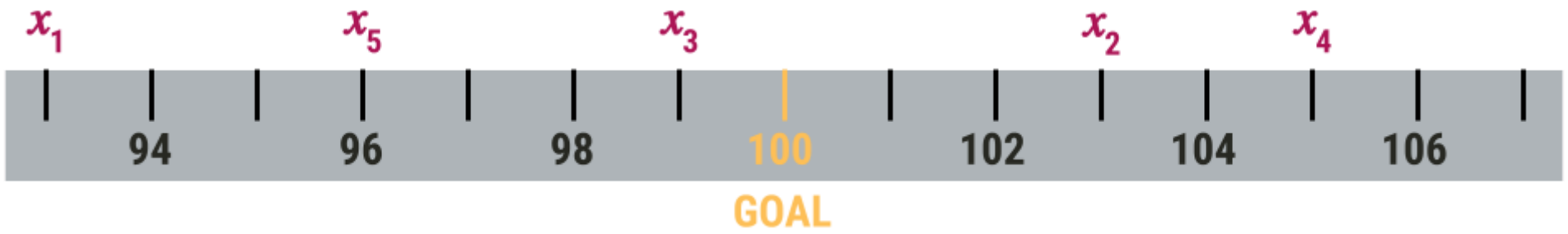
Person	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Jae	80	90	85	82	87
Diane	95	105	100	97	102

What are the mean CE, VE, and AE scores for Jae and Diane?

Person	CE	VE	AE
Jae	-15.2	3.54	15.2
Diane	-0.2	3.54	3.0

Schmidt & Lee 2011; Schutz & Roy 1973 (https://doi.org/10.1080/00222895.1973.10734959)

We can transform CE into absolute constant error



We can calculate using:

$$Mean\,CE = \sum(x_i - T)/n$$

$$Mean\,ACE = |CE|$$

```
# Calculate CE
abs(((93 - 100) + (103 - 100) + (99 - 100) +
```

```
## [1] 0.8
```

Mean ACE = 0.8 cm

Recall AE = 4 cm (See Slide 21)

How do we interpret this?

Learning objectives

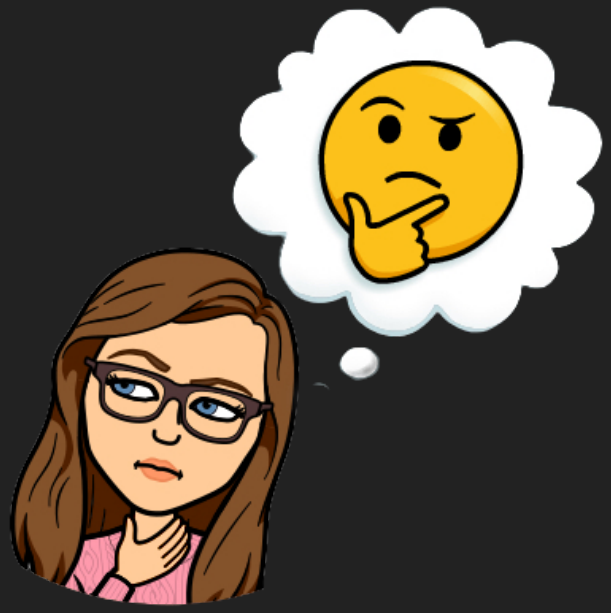
1. Describe the differences between and give examples of **performance outcome** and **performance production** measures.

2. Describe and compute **common error score measures** for different types of motor skills.

Take-home message:

There are many ways we can measure motor performance. Often the appropriate measure depends on the individual, task/skill, and/or environment. Valid conclusions about motor behaviour depend on the use of appropriate measures.

What questions do you have?



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