McMaster University

SCIENCE
Department of Kinesiology

Measuring performance: Reaction time

KINESIOL 1E03 - Motor control and learning

Laura St. Germain
Fall 2021 Week 1
Lecture 4

Updated student hours

- **Wednesdays 11:30 - 12:30**
  - Previously Wednesdays 11:00 - 12:00
- **Thursdays 10:30 - 11:30**
  - Previously Mondays 10:30 - 11:30
- Do these interfere with any other mandatory kin classes?

Review from last lecture

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...

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

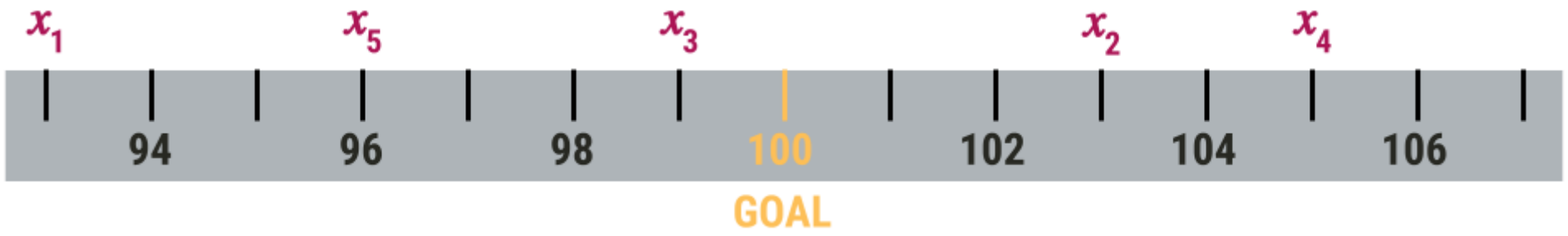
Person	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Jae	80	90	85	82	87
Diane	95	105	100	97	102

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

How do we interpret this?

Any questions?

Learning objectives

1. Describe error scores for **continuous** and **2D motor** tasks, and **temporal** measures of performance.

2. Describe the differences between **simple, choice, and go/no-go** reaction time tasks and be able to provide **research** and **real-world** examples of each.

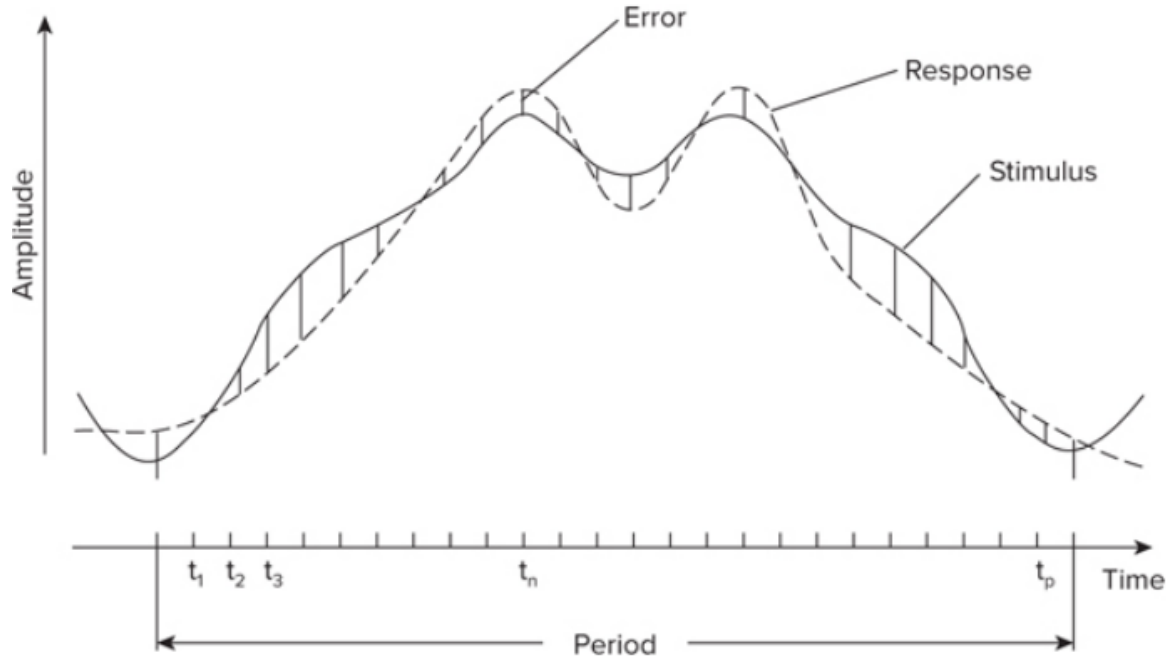
3. Describe three **kinematic** measures of motion and how **electromyography** can be used to provide information about human movement.

4. Identify and describe different techniques for determining **the functions of brain regions** during motor performance.

Take-home message:

Valid conclusions about motor behaviour depend on the use of appropriate measures.

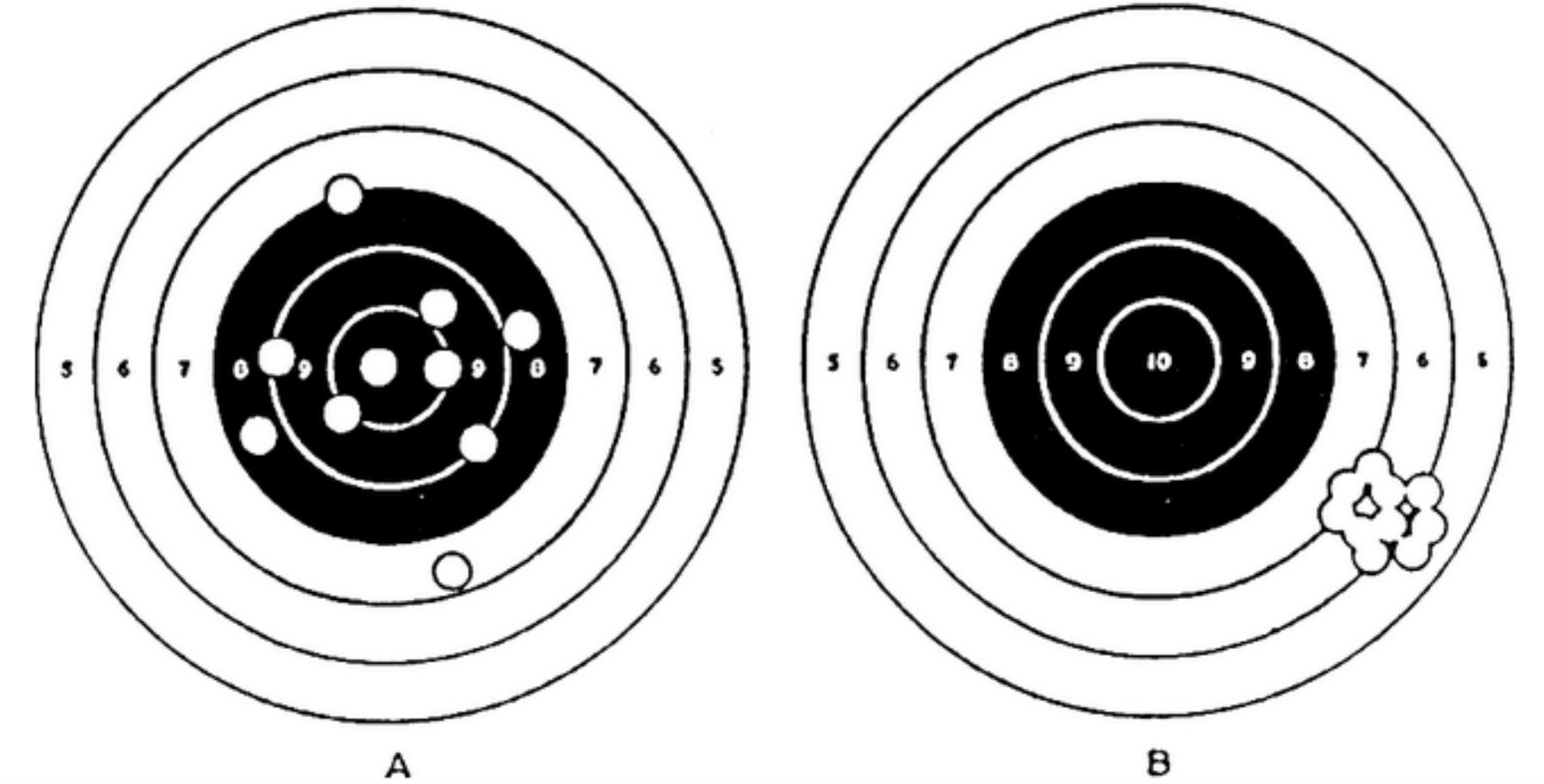
Root mean square error is a measure of overall accuracy



- use displacement curve (response) and target curve (stimulus) to calculate amount of error at predefined points to get RMSE

Franks & Wilberg 1982 (https://doi.org/10.1016/0167-9457(82)90015-X) as cited in Magill & Anderson 2017

Let's return to these targets



Motor tasks that with outcomes that vary in 2 dimensions need to be measured appropriately

Radial error

$$RE = (x^2 + y^2)^{\frac{1}{2}}$$

Subject centroid radial error

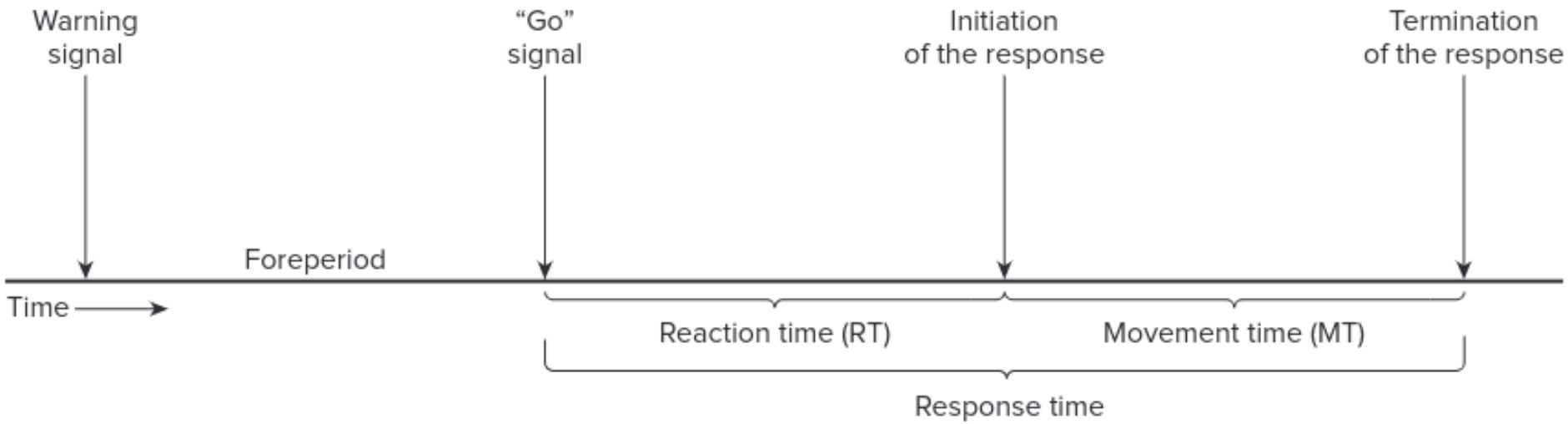
$$SRE = (x_c^2 + y_c^2)^{\frac{1}{2}}$$

Bivariate variable error

$$BVE = \{(1/k)\sum_{i=1}^{k}[(x_i - x_c)^2 + (y_i - y_c)^2]\}^{\frac{1}{2}}$$

Reeve et al. 1994 (https://doi.org/10.1207/s15327043hup0704_6); Hancock et al. 1995 (https://doi.org/10.1080/00222895.1995.9941714); Fischman 2015 (https://doi.org/10.1016/j.humov.2015.05.011)

Reaction time is a measure of the time required to prepare and initiate a movement



MOVEMENT TIME: the interval of time between the initiation and completion of a movement

RESPONSE TIME: the sum of reaction time and movement time

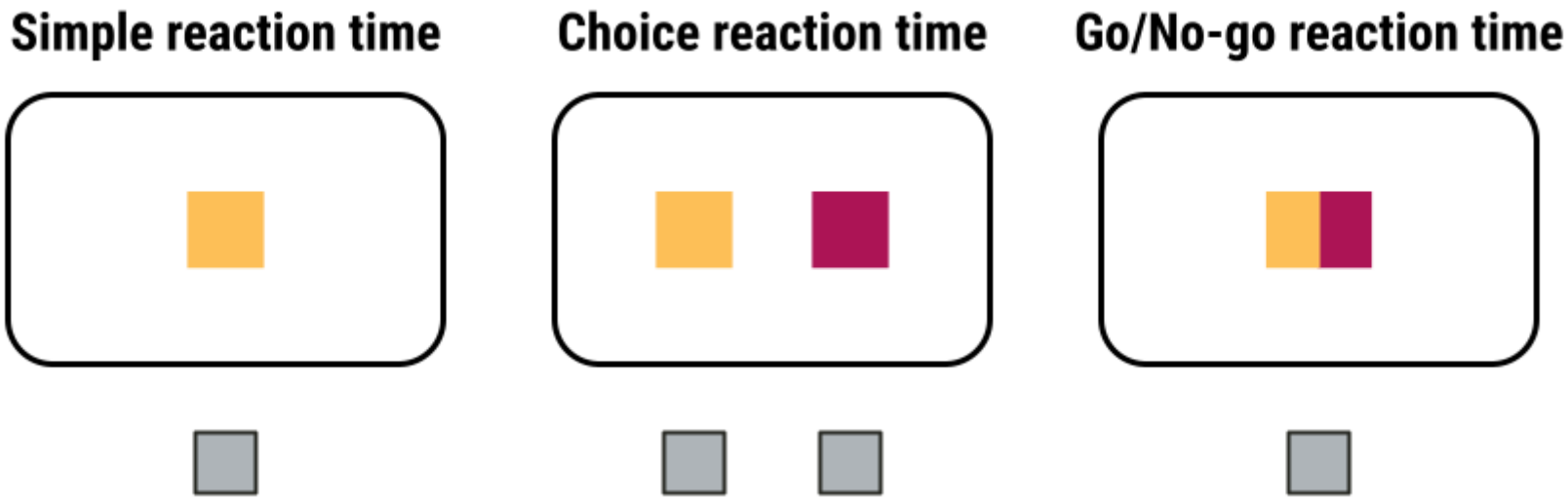
Magill & Anderson 2017 (pg. 29)

Reaction time and movement time are relatively independent performance measures

- Reaction time **does not** predict movement time
- Movement time **does not** predict reaction time
- The person with the **fastest reaction time** in a race may not be the person with the **fastest race time**
- Reaction time and movement time **measure different aspects** of human performance

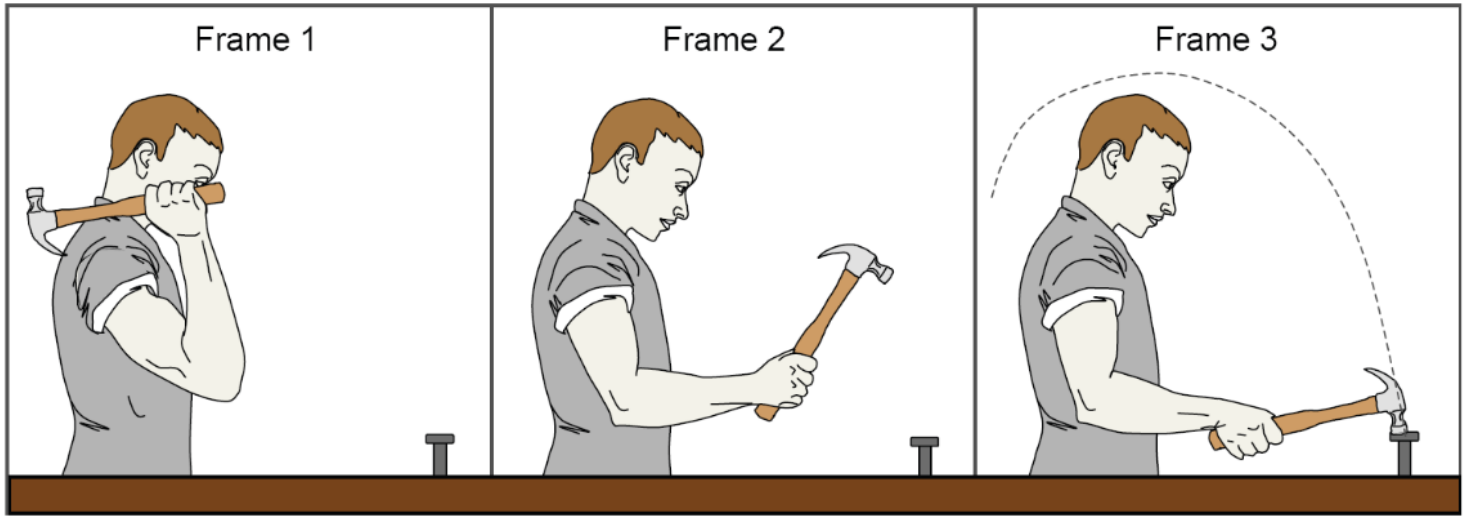
Source: https://upload.wikimedia.org/wikipedia/commons/d/d2/London_2012_Olympic_100m_final_start.jpg

There are three main types of reaction time tasks



- **Simple reaction time**: 1 choice and 1 response
- **Choice reaction time**: 2 or more choices each with a corresponding response
- **Go/No-go reaction time**: 2 or more choices but only 1 is associated with a response

Measuring movement characteristics

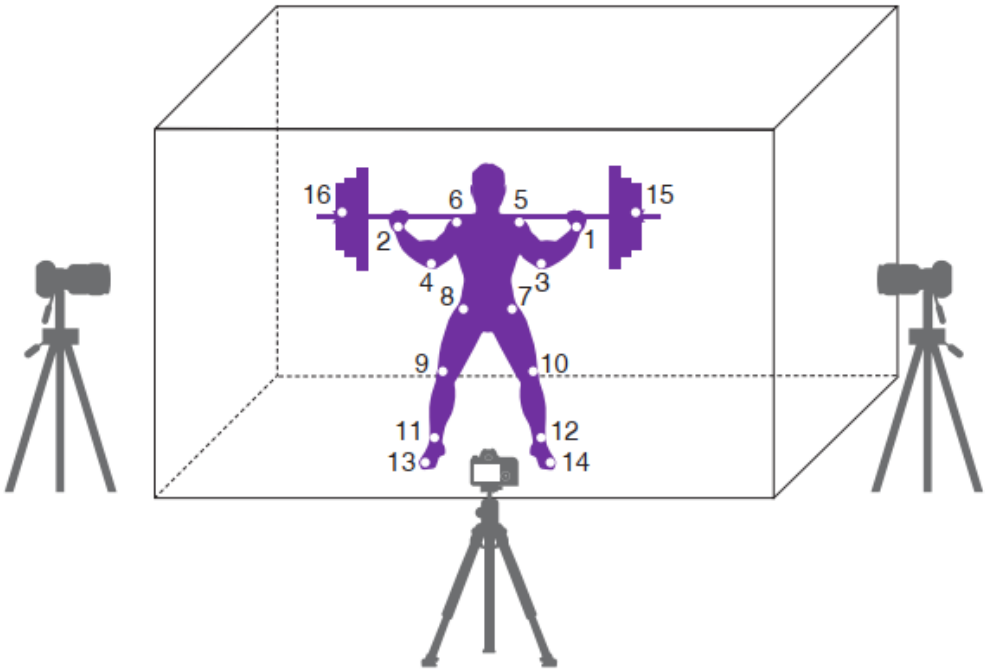


KINEMATICS: the study and description of movement without consideration of the forces that cause the movement (e.g., position, displacement, distance, speed, velocity, acceleration)

DYNAMICS (or KINETICS): the study and description of the causal processes that produce movement (e.g., force and torque)

Fig: Tresilian 2012

We can record someone performing an action and perform a kinematic analysis on their movements

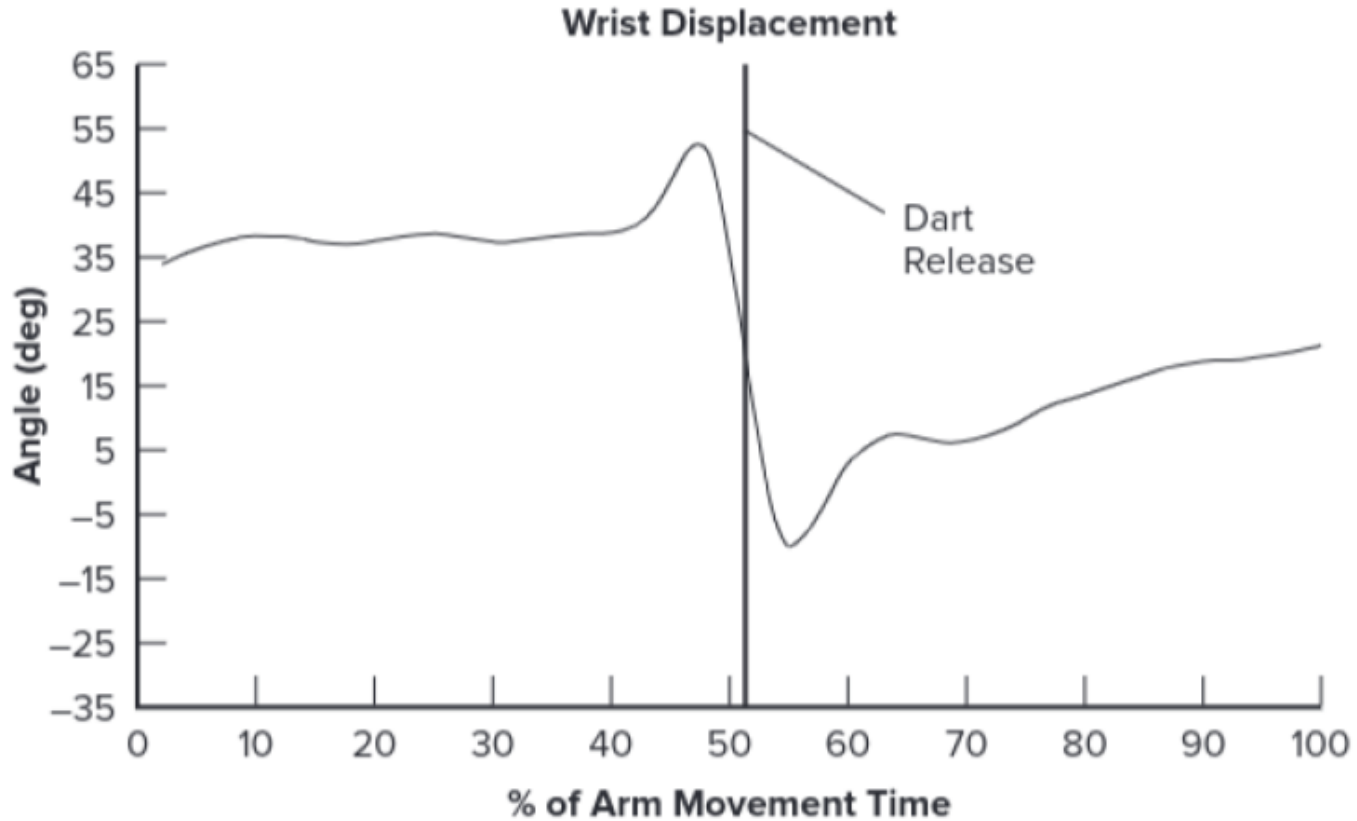


Left: https://www.redalyc.org/journal/5516/551662868010/551662868010_gf2.png; Right: https://beforesandafters.com/wp-content/uploads/2019/08/Xsens-mvn-animate18a.jpg

Let's see motion capture in action...

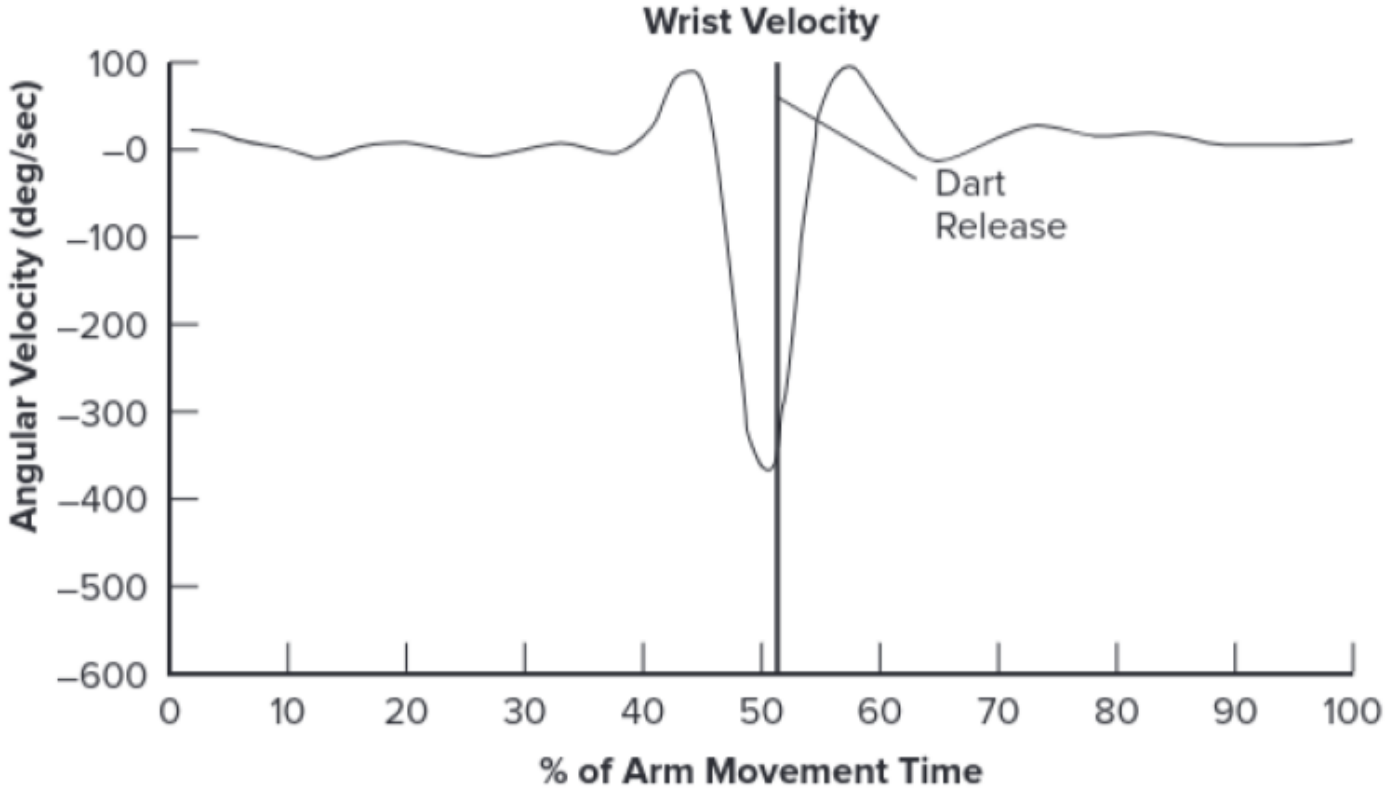
Source: https://youtu.be/CJ-ehBIfXEg

Displacement is the change in spatial position of a limb, joint, or object during a movement



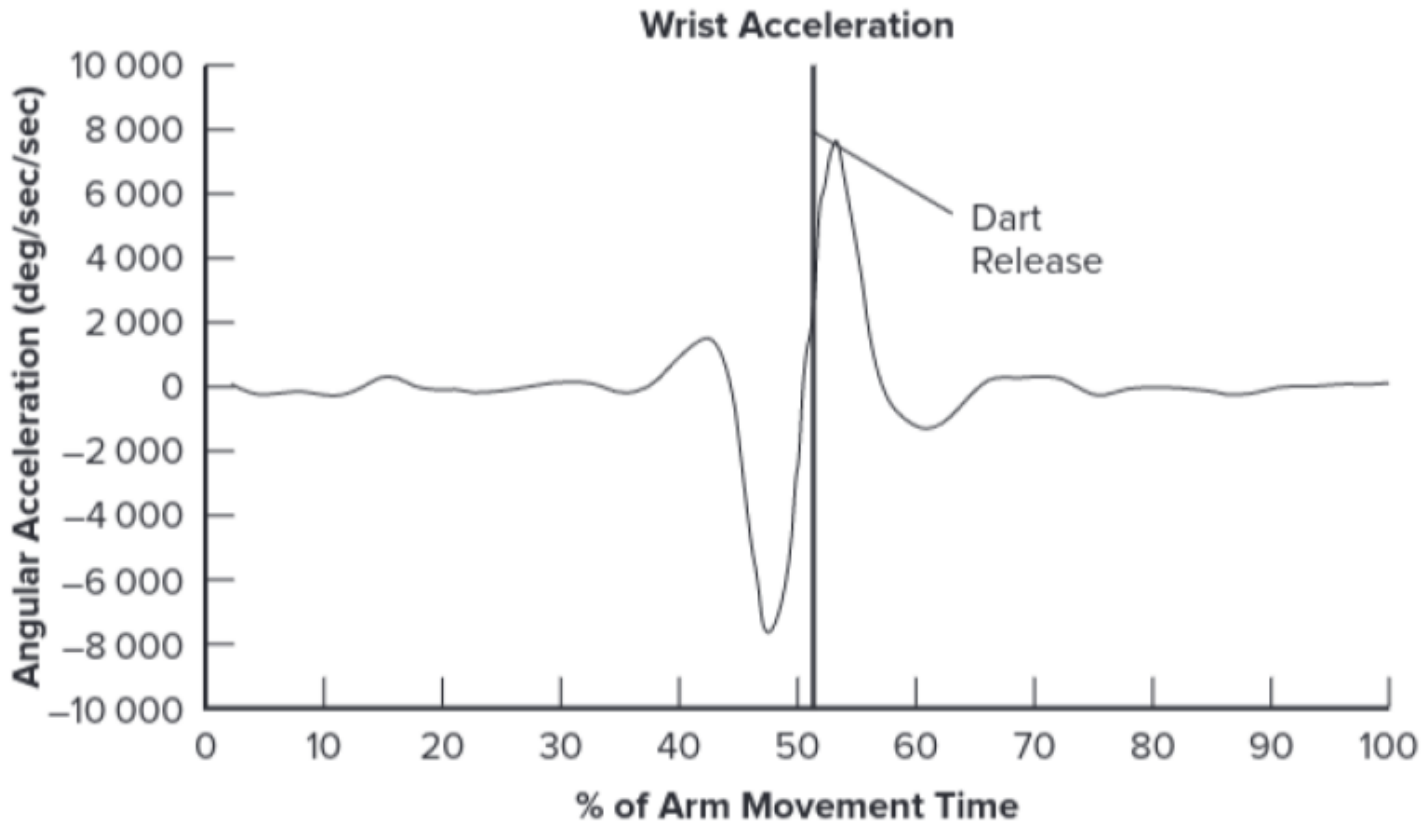
Magill & Anderson 2017 (p. 39)

Velocity describes rate of change in spatial position relative to time



Magill & Anderson 2017 (p. 39)

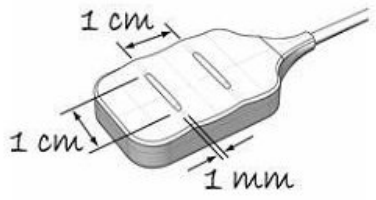
Acceleration describes the change in velocity during a movement

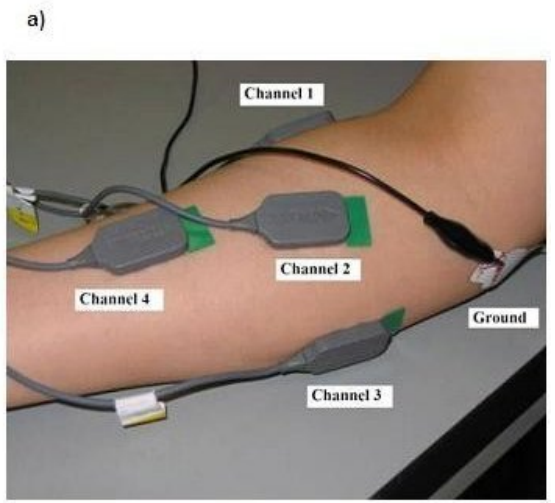


Magill & Anderson 2017 (p. 39)

Motor unit activity in a muscle can be recorded using electrodes placed on the skin

- A typical method involves placing two small electrodes on the skin directly over the muscle of interest (this arrangement is referred to as a **bipolar** configuration)
- A third electrode is placed on the body surface (usually a bone) and is the **ground** electrode
- The recorded signal is a combination of the propagated action potentials from all the underlying muscle fibres that are sufficiently close to the electrodes





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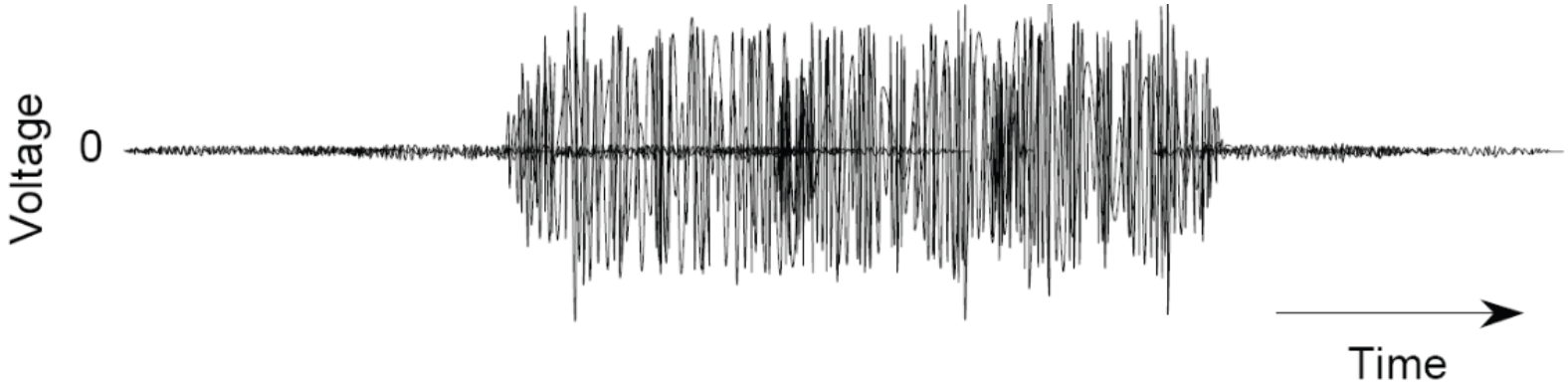


- The amplitude of the electrical signal is very **small** (usually in the order of hundreds of microvolts μV, a millionth of a volt)
- This signal is known as an **electromyographic signal** and the technique of recording these signals is called **electromyography** (EMG)

Fig: Tresilian 2012

Processed EMG signals can be used to obtain measures of muscle activity

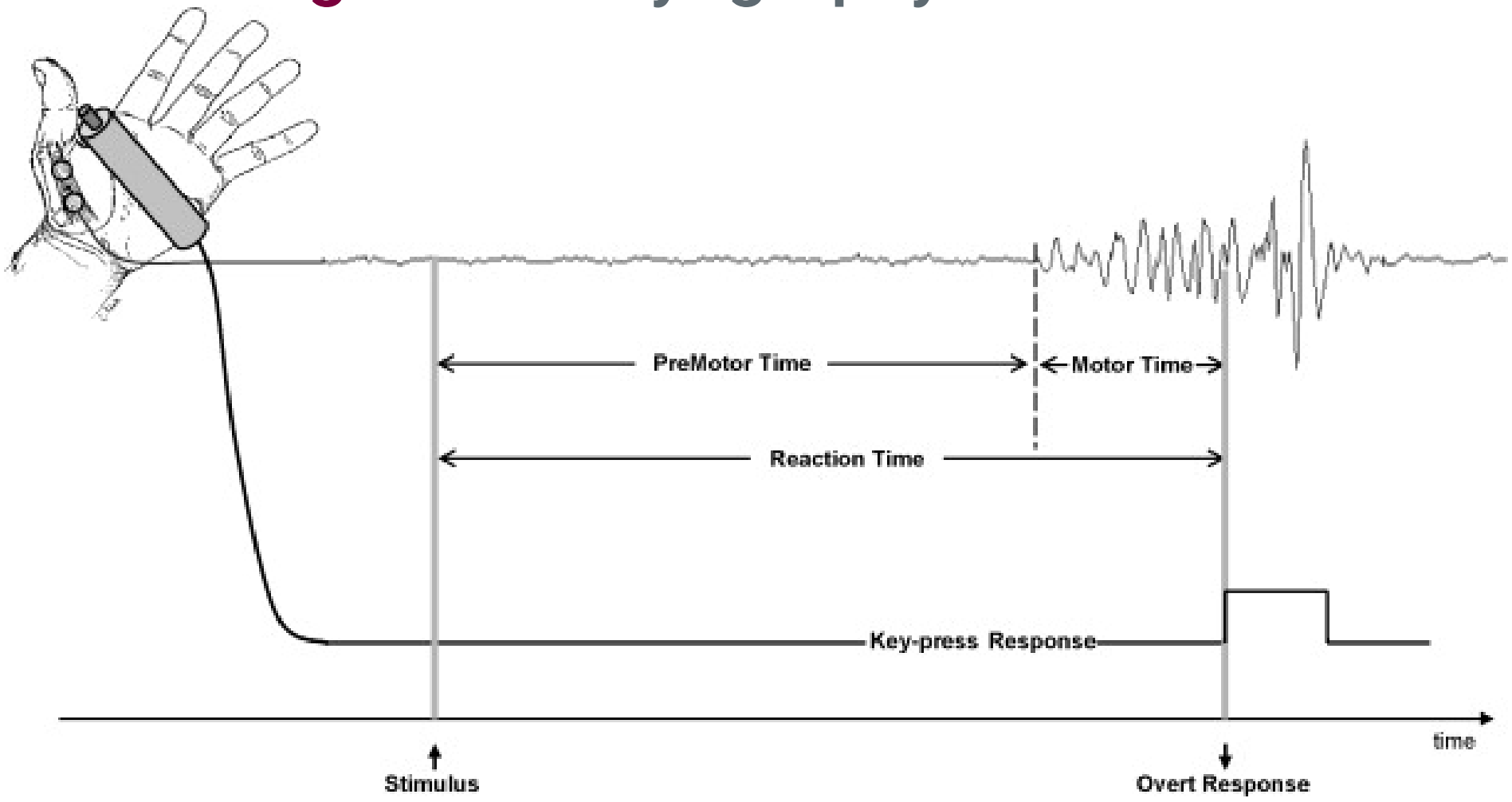
Multiple factors can affect the **quality of an EMG signal**:

- the motor units contributing to the recorded signal
- quality of the i) connection between the skin and the electrodes and/or ii) ground connection
- presence of electromagnetic noise in the recording environment
- size of muscle being recorded from and thickness of subcutaneous fat

If **a good EMG signal** is obtained, it can be used to make various measures of muscle activity:

- when a muscle becomes **active** and **inactive**
- when its activity **changes**
- how **long** it is active for
- how its **level** of activity depends on different conditions

We can gain further insight into the reaction time interval using electromyography



Different parts of the brain are specialized for different functions

This **localization of function** concept can tempt people into making some assumptions without evidence:

LOCALIZATION ASSUMPTION: if there is a neural mechanism that controls or produces some behavioural attribute, then that mechanism is localized to some specific region or structure

FIXED FUNCTION ASSUMPTION: any neural structure or identifiable region that has a particular function (or set of functions) always performs this function (or set of functions) when it is active

Q: How can the functions of brain regions be determined?

Lesion methods can be either destructive or non-destructive

Lesions can occur **naturally** or be **produced by a researcher**

- Naturally occurring
  - Destructive: death of cells due to loss of blood supply (e.g., stroke), mechanical damage or disease processes
  - Non-destructive: May not exist
- Produced by researcher
  - Destructive: removing or cutting tissue, destroying tissue with chemical agents or heat
  - Non-destructive: cooling tissue, applying repetitive magnetic stimulation

Electromagnetic activity of living brains can be recorded

- Electrical activity of neurons in the brain generates **changing electrical fields** that penetrate through the skull
- Small variations in electrical potential can be recorded using electrodes placed on the scalp.
- This technique is called **electroencephalography** (EEG)
- EEG has **good temporal resolution** but **poor spatial resolution**

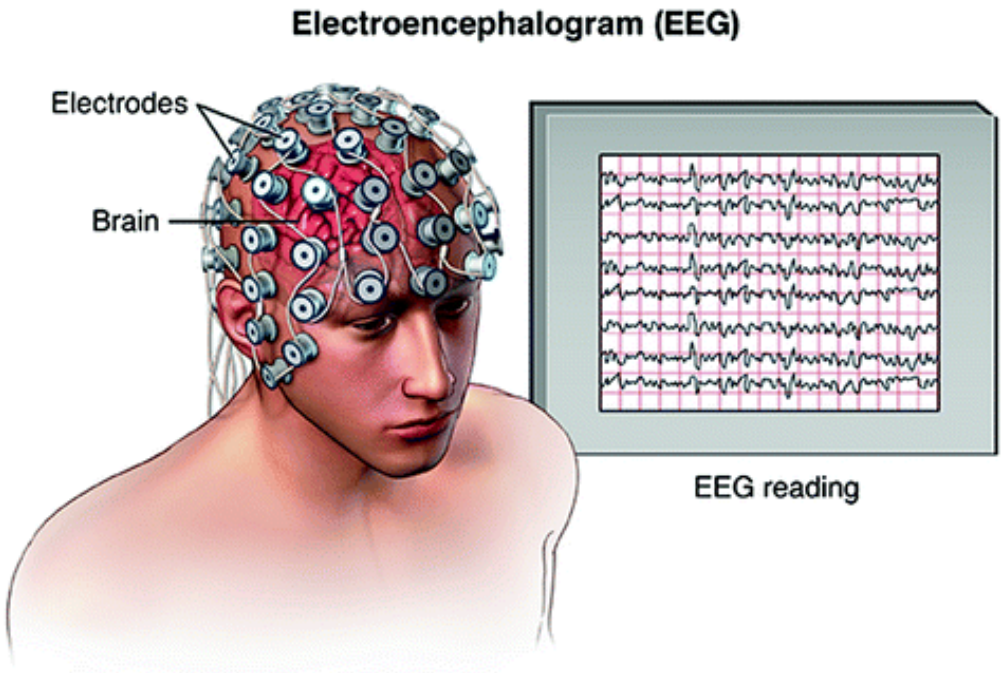
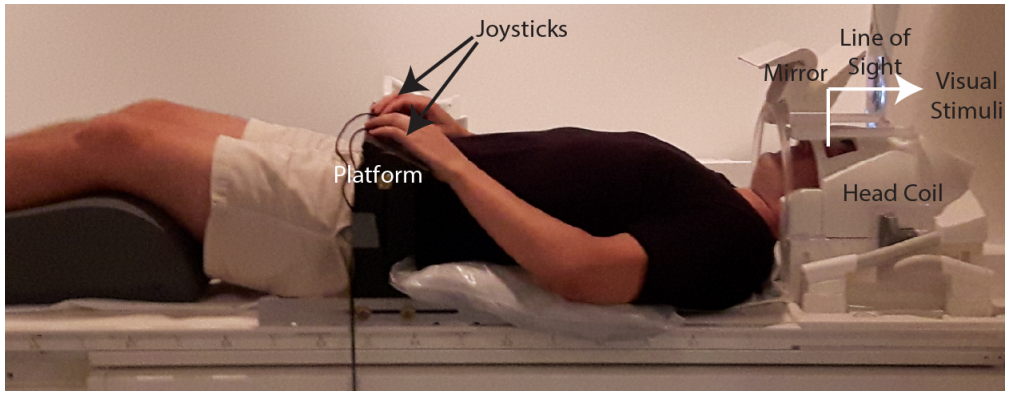
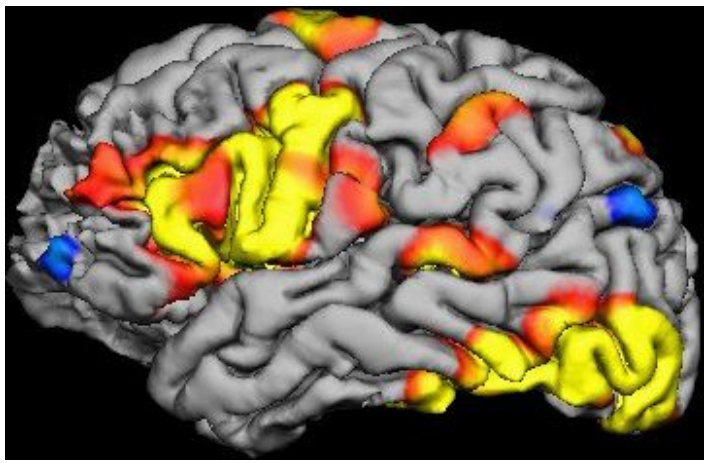


Fig: https://media.springernature.com/original/springer-static/image/chp%3A10.1007%2F978-3-319-47653-7_1/MediaObjects/419678_1_En_1_Fig1_HTML.gif

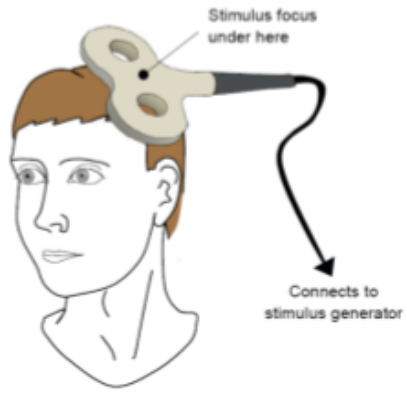
Metabolic activity of living brains can be recorded

- We can measure the metabolic demand of nervous tissue as an **indirect** way of measuring its functional activity
- **More active** the neurons are, the **greater** their metabolic demand (i.e., increased oxygenated blood flow into active region)
- From the radio waves received, a **blood-oxygen level dependent** (BOLD) signal is derived that is a measure of the **ratio** of oxygenated to deoxygenated blood in each **voxel**
- fMRI has **good spatial resolution**, but **poor temporal resolution**

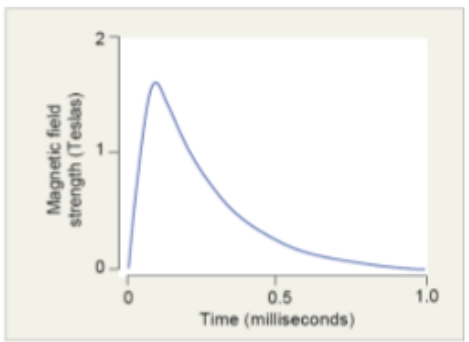




The brain can be stimulated through the scalp



(A) Figure of 8 coil positioned against the scalp



(B) Magnetic field strength over time at the focus

- A popular stimulation technique is **transcranial magnetic stimulation** (TMS)
- Pass a **very brief pulse** of electrical current through tightly wound coils of wire
- When the pulse of electrical current flows through the coil, a **transient but intense** magnetic field is generated
- If coil is held close enough to the scalp, induced currents **depolarize** neurons in the cortical tissue exposed to the changing magnetic field and **causes them to fire**
- Various stimulation protocols exist: single-pulse, paired-pulse, repetitive, etc

Fig: Tresilian 2012

Let's see brain stimulation in action...

Left video: https://youtu.be/cqMTvmLluGg; Right video: https://youtu.be/gp8KnAHkwdo

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Take-home message:

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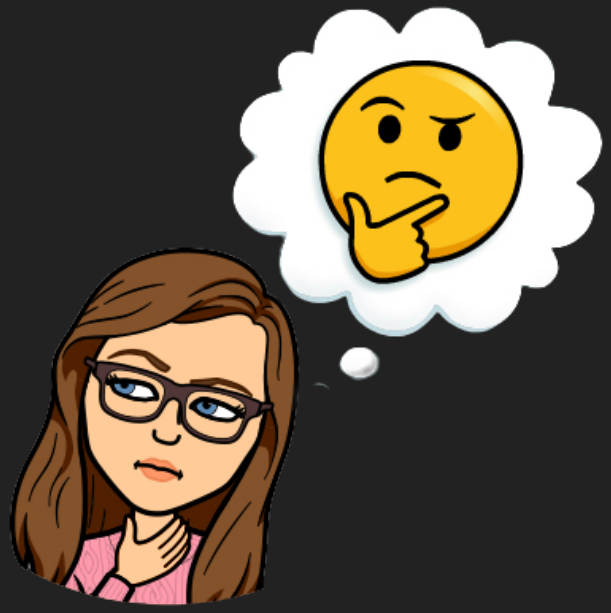
What questions do you have?



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