THE MEASUREMENT OF MOTOR PERFORMANCE
THIS CHAPTER’S CONCEPT

The measurement of motor performance is critical to understanding motor learning & development
PERFORMANCE OUTCOME MEASURES

- Measures that indicate the outcome of performing a motor skill (examples below)
  - Reaction time
  - Error measures
  - Time to completion
  - Number of successful attempts
  - Trial to completion
PERFORMANCE PRODUCTION MEASURES

- Measures something of the movement that led to the outcome (example below)
  - Displacement
  - Velocity
  - Acceleration
  - Joint angle
  - EMG
  - EEG
  - PET (positron-emitting topography)
  - fMRI
Concept 1: Reaction time

- Describe the different types of reaction time and provide examples of each type as it relates to physical rehabilitation, physical education, exercise science, and/or coaching.
REACTION TIME

- RT is the interval of time between the onset of a signal (stimulus) and the initiation of a movement response.

- Types of RT:
  - Simple
  - Discriminate
  - Choice
  - Fractionated
RELATIONSHIP OF RT TO MOVEMENT TIME & RESPONSE TIME.

Warning Signal | Go Signal | Initiation of response | Termination of the response

Foreperiod

Reaction Time | Movement time

Response Time

Chapter 3
Fractionated Reaction Time

Give one an insight into what occurs as a person prepares to move.

Time interval is an indicator of the perceptual and cognitive decision making of the person.
Fractionated RT

- EMG enables one to measure fractionate RT.

- Fractionate RT has two components.
PRE-MOTOR & MOTOR RT

What do you think is happening in each component?
USE OF RT

- Used as a basis for inferring what a performer does or what information a person uses while preparing to produce a required action.

- A long or short RT provides information on how we interact with the environment.
Concept 2: Error Scores

Describe and discuss the different one-dimension errors and what each error score means.
ERROR MEASURES

- Error measures allow us to evaluate performance for skills for which accuracy is the goal.

- Examples of these skills are?
ONE-DIMENSIONAL ERRORS

- Absolute error (AE)
- Constant error (CE)
- Variable error (VE)
Assessing Error for Skills with One-Dimension Accuracy Goals

Three error measures

1. Absolute Error = absolute value of difference between the actual performance on each trial and the criterion for each trial
   - Provides a general index of performance accuracy or overall magnitude of error
   - \( AE = \frac{(\text{performance} - \text{criterion})}{\text{no. of trials}} \)
Assessing Error for One-Dimension Accuracy Goals, cont’d

2. Constant error = Algebraic value of difference between the actual performance on each trial and the criterion for each trial
   - Provides an index of a tendency for the performance error to be directionally biased
   - \( CE = \frac{(\text{performance score} - \text{criterion})}{\text{no. of trials}} \)

3. Variable error = the standard deviation of the CE scores; an index of performance consistency (i.e. variability)
Each archer shot a score of 15 points

Which error score (AE, CE or VE) would determine who is better?
Assessing Error for Two-Dimension Accuracy Goals

- When the outcome of performing a skill requires accuracy in the vertical and horizontal directions
  - e.g. Golf putt
- Radial Error = general accuracy measure for two-dimensions
  - See Figure 2.4
- Performance bias and consistency are difficult to quantitatively assess, although can do qualitative assessment easily
  - See Fig. 2.5
TWO-DIMENSIONAL ERRORS

- Radial error

![Diagram showing radial error with coordinates X=7; Y=5]
Radial Error Example

- Golfer putted to a hole that fell:
  - 2 feet to left (horizontal)
  - and 1 foot short (vertical) of the hole

- Radial error is calculated by
  - Measuring the length of the error horizontally then square the value \(2^2 = 4\)
  - Measure the length of the error vertically then square the value \(1^2 = 1\)
  - Add the squared X & Y values \(4 + 1 = 5\) then square root the total (Radial error = 2.23)
ASSESSING ERRORS FOR CONTINUOUS SKILLS

- Root-mean-squared error (RMSE)

- RMSE determines the amount of error between a displacement curve produced by the subject’s tracking performance and the displacement curve of the criteria performance.

- E.g diving your car on the interstate

- See Figure 2.6 of your text
Concept 3: Kinematic measures

Describe and identify the different types of kinematic measures and provide an example of each type that relates to your future profession.
KINEMATIC MEASURES

◆ **Displacement (spatial location)**
  ★ Spatial position of a limb or joint over a period of time

◆ **Velocity (rate of change)**
  ★ Rate of change in an object position with respect to time (Velocity = displacement/time)

◆ **Acceleration (change of velocity)**
  ★ Change in velocity during movement (Acceleration = velocity/time)
Figure 2.6 Angle-angle diagrams showing knee-thigh relationships during running by a skilled runner (top) and three below-knee amputees (bottom). The abbreviations indicate ipsilateral (left) footstrike (IFS), ipsilateral takeoff (ITO), con-
KINETICS

- Kinetic refers to force as a cause of motion.
- Newton’s 3 laws of motion are used to understand the role of force.
  ★ Force is presented as necessary to start, change, or stop motion.
  ★ Forces influences the rate of change in the momentum of an object.
  ★ Force involves a action and reaction between two objects.
- Joint torque (rotary force) involves rotation of body segments around joint axes.
EMG

- Shows electrical activities in the frequency and amount of involvement of each muscle measured in a movement.

- Shows the start and end of activity of a specific muscle in a movement.
FIGURE 2.8  Using EMG recordings to measure a movement response. The figure on the left shows the reaction-time appa-
Concept 4: Brain Activity Measures

- Describe the different types of brain activity measures and their purpose.
Brain Activity Measures

- Researchers have adopted brain activity measures commonly used in hospitals and clinics for diagnostic purposes.
- Three measures commonly reported in motor learning and control research:
  - EEG
  - PET
  - fMRI
Brain Activity Measures, cont’d

- Electroencephalography (EEG): Measures electrical activity in brain
  - Active brain regions produce electrical activity

- Positron Emission Topography (PET): Neuroimaging (i.e., brain scanning) technique that measures blood flow in the brain
  - Active brain regions involve increased amounts of blood flow
Brain Activity Measures, cont’d

- Functional Magnetic Resonance Imaging (fMRI): Neuroimaging (i.e., brain scanning) technique that measures blood flow changes in the brain by detecting blood oxygenation characteristics.

To see examples of PET, fMRI, and other brain scanning techniques, go to http://www.pbs.org/ and type “brain scanning” in the Search box.
EEG (electroencephalography)

- Neurologists commonly use EEG to assess brain disorders.
  - Active brain regions produce electrical activity
  - Noninvasive and painless procedure of placing 4-16 surface electrodes on the frontal, central, parietal, and occipital lobes for right and left hemisphere.
  - Brain activity is rhythmic (waves) & measurable:
    - Beta (fast waves when cortex is active)
    - Alpha (occurs when brain is quiet; one is awake)
    - Theta (slow wave during sleep)
    - Delta (slowest wave…deep sleep)
EEG
Neuroimaging

- Neuroimaging (*i.e., brain scanning*) technique that measures blood flow in the brain
- Active brain regions involve increased amounts of blood flow
- Types
  - PET
  - Meg
PET (positron emission topography)

- Used to provide clear and precise images of the activity of brain
  - Show blood flow or metabolic activity in brain
  - Inject or inhale radioactive solution
- Researchers engage a person in performing a motor skill while the scanner surrounds the head.
fMRI (magnetic resonance imaging)

- Neuroimaging (*i.e.*, brain scanning) technique that measures blood flow changes in the brain by detecting blood oxygenation characteristics.
- Produces an image of any part of the body from any direction in “slices.”
  - fMRI determines brain function in terms of blood flow changes.
MEG (magentoencephalography)

- Assesses magnetic fields created by neuronal activity of the brain.
  - Directly measures the function of brain
  - Has a very high temporal resolution to determine damaged brain tissue
  - Used to observe people performing cognitive and motor activities.
TMS (transcranial magnetic stimulation)

- Measures motor activity via a scan of the brain and recording electrical, magnetic, or bloodstream activity.
  - Place a coil on a person’s skull at brain cortex area of interest.
  - Short burst of magnetic waves then disrupts brain activity at the area of interest.
Concept 6: Movement-Related Coordination Measures

- A person performs a motor skill in a specific time (temporal) and space (spatial).
  - One way to measure a person performing is to create a graphic angle-angle plot of the movement joints.
    - Angle (X) – angle (Y) plot at specific times during the movement can be compared (cross correlation).
  - Another way is a person repeats a movement pattern for a certain amount of time (relative phase).
    - From repeating the movement one can gain a sense of the relative timing of the movement.
    - Phases of the movement (parts of movement) can be described by a displacement-velocity graph of the temporal and spatial characteristics.
SUMMARY

- Understanding the measure used to assess a motor performance provides a better understanding of one’s behavior or performance.
  - One’s rate of learning
  - One’s present status of a motor or sport skill
  - Help’s identify deficiencies
  - Provide a quantitative or qualitative aspect of one’s performance