

# Human Movement

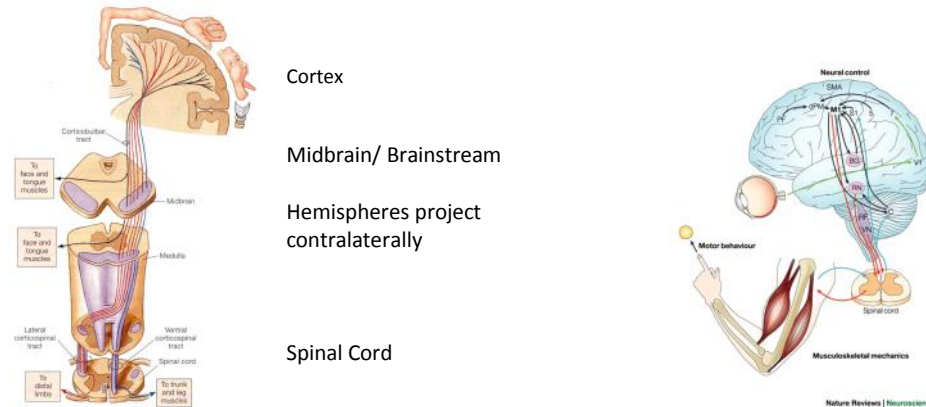
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## Motor Control: Lecture 1

### Defining Motor Control

- Refers to the nervous system's control of muscles to permit skilled and coordinated movement

### Basic overview of CNS



### What Can Happen?

- Variety of movement disorders:
  - o Parkinson's
    - Neurodegenerative disease
    - Produces a variety of movement complications
    - "Off Period" no medication
    - Related to level of transmitters in the ganglia (dopamine and acetylcholine)
    - Death of dopamine-generating cells in midbrain
    - Shaking, rigidity, slowness, difficulty walking
    - Mostly in elder patients
  - o Cerebellar ataxia
    - Damage to the cerebellum in the brain
    - Indirect effect from right side of cerebellum and body (right side damaged means left side of body is affected)
    - The problem is at the endpoint of the movement, when the patient attempts to fix, the correction is over fixed.
    - Complex motor disturbance
    - Inability to coordinate balance, gait, extremity and eye movements
    - Tremors at the end point of a movement caused by over-autocorrection
    - Causes are MS or Trauma
  - o Dystonia
    - Neurological movement disorder
    - It occurs when the brain has improper electrical impulses, causing sudden muscle contractions (non voluntary)
    - Improper electrical signals from brain causing awkward tightening and twisting of the muscles
    - 300 000 people in North America
    - 1/3 diagnosed are children
    - Causes pain from awkward positioning
    - Twisting, repetitive movements or abnormal postures
  - o Cerebral Palsy
    - Describes a persistent disorder of posture caused by the abnormality of the brain that is immature that lacks progression
    - Causes:
      - before time of birth, poor development of the brain
      - Trauma in the womb. (motor milestones)
    - Problems in the movement, fits, hands and feet move improperly
    - Caused by abnormality in the brain
    - Risk is elevated in premature infants
    - Effects movement in various ways

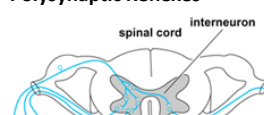
### Researchers in SHK: Dr. Cressman

- Dr. Cressman's research examines how the brain processes sensory information for goal-directed action
- Dr. Carlsen's research focuses on the early preparation and initiation of voluntary movements and their associated synergies in both health populations and populations with disordered movement

### Unit of Action: Reflex

- Reflex arc:
  - o Receptor, conductor, effector
  - o (Discovered by Sir Charles Sherrington)
- Stimulus - Response
  - o Knee jerk reflex

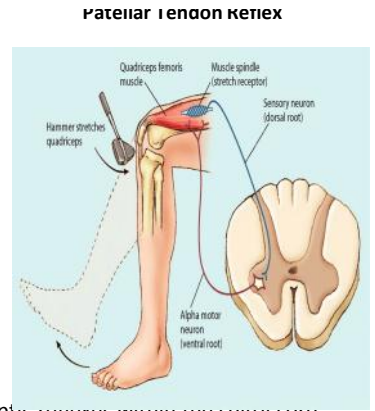
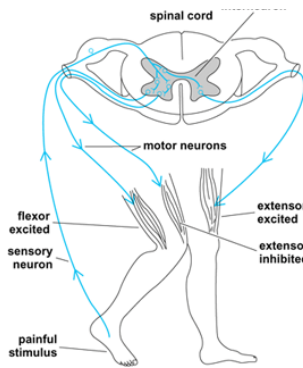
### Polysynaptic Reflexes



### Patellar Tendon Reflex



- Receptor, conductor, effector
- (Discovered by Sir Charles Sherrington)
- Stimulus - Response
  - Knee jerk reflex
- Simple Reflex
  - Tap on the patellar tendon
  - Quadriceps extend
  - Stretch receptor tells spinal cord (dorsal root)
  - Spinal cord activated alpha motor neuron (ventral root)



### Polysynaptic Reflexes

- More than one synapse involved
  - More complex movement generated via the reflex control
  - One or more interneurons connect afferent (sensory) and efferent (motor) signals
  - All but the most simple reflexes are polysynaptic, allowing processing or inhibition of polysynaptic reflexes within the spinal cord

### Latency of Response

- Refers to the time between the stimulus, and a muscle activation response
- Measured through electromyography (EMG)
- Knee jerk reflex typically has a response latency of 40-80msec
- In laboratory session, you will use reaction time (RT) as an index for response latency

### Sherrington's chaining of reflexes (late 1800s - early 1900s)

- Sherrington's work was with decorticate cats, dogs, and monkeys
- He argues that movements can be controlled at the level of the spinal cord through a changing of reflexes
- Carefully described and defined reflexes
- Formed the experimental foundation for a classic reflex theory of motor control
- Believed reflexes worked together or in sequence to achieve a common purpose (1947)

### Limitations of Sherrington's ideas

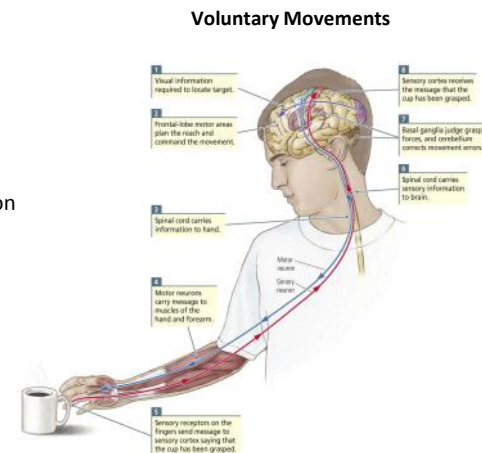
1. Voluntary movements can be activated without a stimulus triggering the movement (outside active agent)
2. Research has shown that movements can occur in absence of sensory input (Tabeb and Berman, 1968)
  - a. You can have reactions without afferent information
3. Cannot explain rapid movement sequences
4. A given stimulus can result in different responses depending on context and descending commands
  - a. Overriding natural movement

### Our Researchers

- Limitations
  - Deafferentation in humans
  - Professor Yves Lajoie
    - Worked with a woman referred to as "GL"
    - GL had no sensory information concerning touch, tendon vibration and proprioception
    - GL was able to carry out her activities using only visual sensors

### Voluntary Movements

- Goal directed movements initiated by the individual
  1. Visual information required to locate target
  2. Frontal-lobe motor areas plan the reach and command the movement
  3. Spinal cord carries information to hand
  4. Motor neurons carry message to muscles of the hand and forearm
  5. Sensory receptors on the fingers send message to sensory cortex saying that the cup has been grasped
  6. Spinal cord carries sensory information to brain
  7. Basal ganglia judge the grasp forces, and cerebellum corrects movement errors
  8. Sensory cortex receives the message that the cup has been grasped



### Voluntary Response Latency

- For voluntary movements, latency of response is about 120-180 milliseconds, depending on task and circumstances
- Voluntary reactions require the person to pass through three stages of information processing and requires attention
- Response latency can be affected by a host of factors:
  - Number of stimulus response alternatives
  - Instructions
  - Performer's anticipation

### Comparisons

- Reflex Movements:
  - Initiated by stimulus, afferent information
  - Requires no conscious attention or information processing
  - Has a typical response latency of 40-80msec
- Voluntary Movements:
  - Stimulus not required, based on psychological and behavioural decisions.

- By goal
- Requires attention and information processing
- Typical response latency of 120-180msec

## Lecture 2: Motor Development

### Motor Development

- The study of the changes in human motor behaviour over the lifespan, the processes that underlie these changes and the factors that affect them
- Targets both early age and understanding the aging process in general

### Motor Development Continuum

Phase	Approximate Age	Stage
Reflexes/ Spontaneous movements	Conception - 1 year	Prenatal and Infancy
Rudimentary motor skills	Birth - 2 years	Infancy
Fundamental motor skills	2 years - 6 years	Early Childhood
Sport/ specialized skills + Growth and refinement	6yrs - 12yrs 12yrs - 18yrs	Late childhood Adolescence
Peak Performance	18yrs - 30yrs	Adulthood
Regression	40s-100s	Mid - Older Adulthood

- Infants will be randomly moving parts of the body even when at rest
- Asymmetric function pattern when working one part of the body to the next
  - Caused by basic stimulus, not voluntary in infants

### Spontaneous and Reflex Movements

- Newborn examinations
  - Include reflexes
- These examinations provide us with valuable information concerning neurological development
  - Ex: Balance
    - Elderly will lose this sense of balance thus the reflex of catching one's self is lost

### Rudimentary Movements

- Rudimentary motor skills end at about 15 months of age where the child begins to walk
  - Follow 2 principles
    - Cephalocaudal: the head down to the feet
    - Proximodistal: the core
  - Growth: all the body systems and the measurable qualitative changes.
  - Maturation: just general qualitative changes.
    - Cephalocaudal:
      - Lifting head and balancing legs
    - Proximodistal:
      - Grabbing furniture

### Fundamental Motor Skills

- Examples:
  - Catching a ball
  - Throwing a light ball
  - A long jump swimming
- Developmental sequences for FMS
  - Biomechanical descriptive period
    - Lolás Halverson
    - Longitudinal observations of children doing varied FMS
    - Stages of development for many of the FMS
      - Example: throwing a ball
- Importance:
  - If you can't run, you won't take part in sports

### Why Study Motor Development?

- Human motor development is multifaceted; consisting of such domains as cognition, emotion, intelligence, etc.
- Given the continual interactions among the varied domains we can never understand human development without including the motor domain
- Understanding the typical motor development allows us to diagnose cases where abnormal development is occurring that warrants intervention and remediation
- Understanding typical motor development enables creation of developmentally appropriate activities for optimal teaching/ learning motor skills for people of all ages

### Perspectives on Development

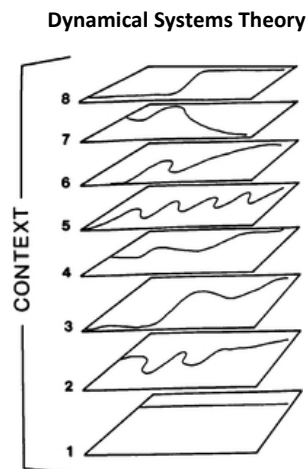
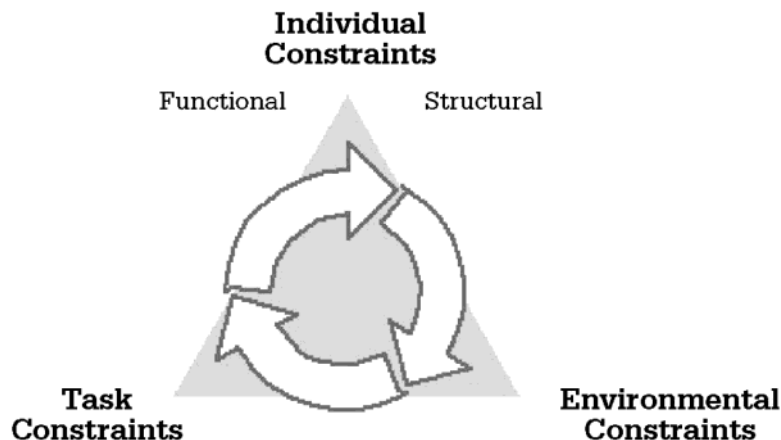
- Dynamical systems (Kugler, Kelso, Turvey-Bernstein)
  - Organization of physical and chemical systems constrains behaviour
  - Structure of adult human hip joint encourages (constrains) upright walking

- Motor skill development is the product of many underlying systems (nervous, skeletal, muscular, etc.)

**Tenets of Dynamic Systems Theory**

- All systems have their own rate of development
- The skill will emerge when all systems are at the level needed to perform the skill
- The last system to "kick in" is called the rate limiting system

**Newell's Model**



**Functional Constraints**

- Behavioural function
  - o Motivation, fear, attentional focus

**Structural Constraints**

- Body system structure
  - o Changes with growth and aging
  - o Changes tend to occur slowly over time
    - Height, weight, muscle mass, leg length

**Environmental Constraints**

- Both physical and sociocultural
- A property of the world around us
  - o Temperature, amount of light, humidity, gravity
  - o In the 1950's, society did not expect girls to participate in sport; as a result, girls were channeled away from sport

**Task Constraints**

- Related to rules of activity and equipment used
- Goals of a movement of activity
  - o Specific to the task
    - You must dribble in basketball
- Equipment used is a constraint
  - o Strung racquet compared to a wooden paddle in racquetball
  - o Decreasing the net height in youth volleyball

**Lecture 3: Motor Learning**

**Motor Learning**

- Refers to the relatively permanent gains in motor skill capability associated with practice or experiences

Performance	Learning
Observable behaviour	Inferred from performance
Temporary	Relatively permanent
May not be due to practice	Due to practice
Influenced by performance variables	Not influenced by performance variables

**Learning**

- A change in the capability of a person to perform a skill that must be inferred from a relatively permanent improvement in performance as a result of practice or experience (Magill, 2010, p.249)
- Performance affected by performance variables
  - o Not necessarily learning variables
  - o Factors that affect a person's performance but not the degree of learning that has already been achieved

## Learning Characteristics

1. Improvement
  - Increased level of skill at a later time compared to an earlier time
2. Consistency
  - As learning progresses, performance is more consistent
3. Stability
  - Skill not affected so much by perturbations (internal/ external)
  - Skill performance (internal)
  - Environmental (external)
4. Persistence
  - Increased amount of persistence of performance capability over a longer period of time (today, tomorrow ---> next week)
5. Adaptability
  - Increased capability to adapt to a variety of performance and context characteristics

## Assessing Learning

- Performance curves
  - Record levels of performance
  - Error measures
    - Constant error (bias)
    - Variable error (consistency)

## Performance Curves

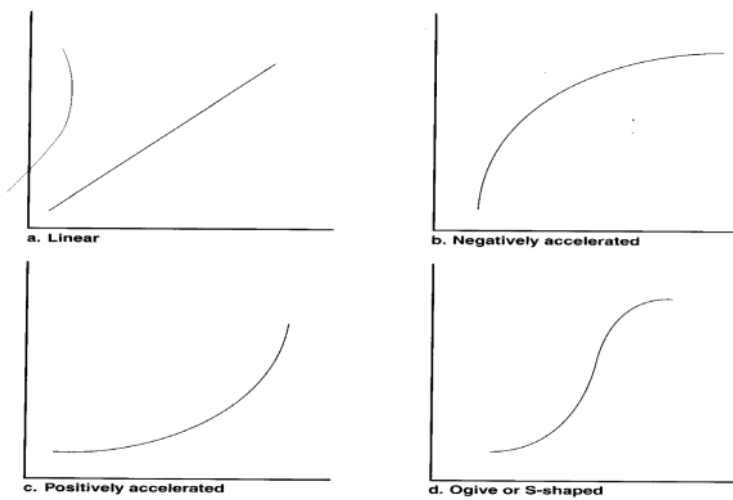


FIGURE 11.2 Four general types of performance curves. Each curve is based on higher performance scores (which would be on the y- or vertical axis) representing better performance than lower scores.

## Linear Curve

- Proportional increase over time
  - Each unit of increase on the x-axis results in a proportional increase on the y-axis

## Negatively Accelerated Curve

- Large amount of improvement early in practice, but improvement decreases as time passes
- Most prominent type of performance curve for motor skill learning
  - Classic power law of skill learning

## Positively Accelerated Curve

- Slight improvement early in practice, but substantial increases later in practice

## S-Shaped Curve

- Combination of 2 and 3, slow improvement, rapid and then plateau

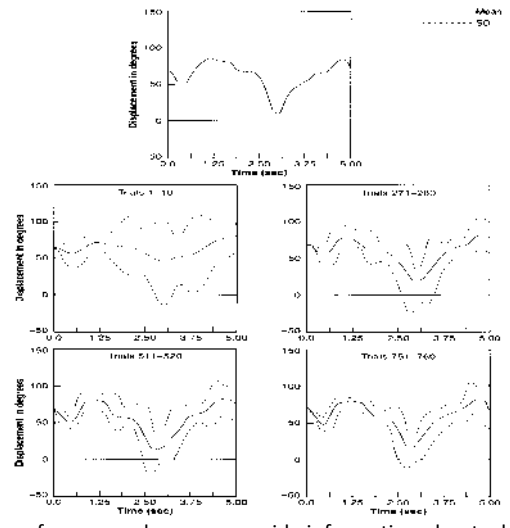
Sometimes "less is more"

- A downward slope would indicate improved performance when the performance measurement being taken was error (time)
  - A decrease in time would be seen as an improvement

## Kinematic Performance Curves

- Kinematic measures are performance production measures
  - Three common kinematic measures are:
    - Displacement
    - Velocity
    - Acceleration
- Plot a sample of the trials at different points in acquisition

FIGURE 11.3 Results of the experiment for the retention and transfer tests. The top graph shows the displacement in degrees over time (sec) for the retention test. The bottom four graphs show the displacement in degrees over time (sec) for the transfer tests. The y-axis for all graphs is Displacement in degrees, ranging from -50 to 150. The x-axis for all graphs is Time (sec), ranging from 0.00 to 5.00. The top graph shows a mean displacement of approximately 100 degrees with a standard deviation (SD) of about 20 degrees. The bottom four graphs show similar trends for different trials.



- But practice performance alone can provide information about which three learning characteristics?
  - May lead one to misinterpret learning effects
  - Why?
    - Transient effects of the "instruction feature"
      - Artificial Inflation
      - Artificial Deflation

**How do we overcome this?**

- Retention and transfer tests
- **Retention test:**
  - Interval of time passes after practice and person is asked to perform same task again
  - In experiment - remove manipulation
  - Compare with first learning blocks
- **Transfer tests:**
  - Novel situations adapted to the characteristics of a new situation
  - 1. Novel context characteristics
    - Change physical environment
    - Change performance situation
  - 2. Novel variation of skill
    - Perform a variation of the skill

Retention	Transfer
Improvement	Adaptability
Persistence	Improvement
Stability	Persistence
Consistency	Stability
	Consistency

**Winstein et al., (1996) KR Study**

- Partial weight bearing task (30% of body weight while on crutches)
  - Concurrent KR vs. Terminal KR
  - Practice data showed:
    - Concurrent: 2% error
    - Terminal KR5: 6% error
    - Without retention test, Concurrent KR seems to be best condition for learning
  - Two days after the practice session, participants attempted the same task
  - Retention data showed:
    - Concurrent: 10%
    - Terminal KR5: 6.5%
- The passive guidance benefits in a short term practice and learning, but since the subject is not doing the work for themselves, he/she cannot retain as well. Task intrinsic feedback
- KR5 condition reflects therapy goal (perform partial-weight-bearing task in daily life)

**Performance Plateau**

- While learning a skill, a period of time in which the learner experiences no improvement after having experienced consistent improvement; typically, the learner then experiences further improvement with continued practice