Motor Behavior
- investigation of principles of human movement

Motor control
- the study of the neurophysiological factors that affect human movement

Motor Learning
- the study of practice in acquiring and perfecting motor skills

Motor Development
- What is your definition???
Motor Development

- the study of changes in motor behavior which reflect the interaction of the maturation and the environment

- the study of changes in motor behavior across the lifespan, the processes which underlie these changes, and the factors that affect them
Lifespan Approach
- study the individual through both the progressive and regressive phases of development
- Ex. ???

Product Approach
- task-oriented
- end result or outcome is the focus
- performance scores
- quantitative
- Ex. ???

Process Approach
- emphasizes the movement itself
- form and function
- qualitative
- Ex. ???
Interdisciplinary Approach

- examine the acquisition of movement skill as a child ages
- examine underlying neurophysiological factors as they change with aging
- examine differences in joint angles in gait across ages

Importance

- understanding normal development enables us to diagnose and provide proper intervention for developing disabled
- helping perfect or improve movement performance
- to create an physical education curriculum
Development in General

All-encompassing – motor, intellectual, social, emotional

Qualitative – “not just more”, technique changes

Sequential - orderly appearance of certain motor patterns

Cumulative – new behaviors are built on previous ones

Directional – progressive or regressive

- Cephalocaudal - maturation proceeds head to “tail”
  Ex. ???

- Proximodistal - maturation proceeds from points closest to the body’s center to the periphery
  Ex. ???
Research Design

Cross-sectional
- Technique used to imply development by studying groups of varying ages at one time
  Ex. ???

Longitudinal
- Technique in which the same individual is observed performing the same task over along time to determine developmental change
  Ex. ???

Sequential (Cohort)
- Technique combining longitudinal and cross-sectional observations.
- Some subjects are observed over the full length of the study whereas other are monitored part of the time or just once.
  Ex. ???
Stage
- phase, periods, transition
- qualitatively different
- hierarchical
- ordering invariant
- common universally
Ex. ???

Controversy
- continuous or discontinuous?
Ex. ???
Fine Motor Control
- movements produced by small muscles
- usually involves the hands or fingers
  Ex. ???

Gross Motor Control
- movements produced by large muscles
- movements that move the body in space
  Ex. ???
**Manipulation**
- skillful use of the hands
  Ex. ???

**Intrinsic Movements**
- coordination of the fingers with an object already in the hand
  Ex. ???

**Extrinsic Movements**
- move the hand and object using the upper limb
  Ex. ???
Simple Synergy
- action of all fingers and thumb are similar
Ex. ???

Reciprocal Synergy
- combinations of finger and thumb movements
- reciprocal and simultaneously interacting to produce different movements
Ex. ???

Sequential Patterns
- a sequence of hand movements
Ex. ???
Exploratory Procedures

- manipulation enables increased and varied exploration

- use of hands enables child to gain information, particularly haptic, about their environment in a new way

- let’s child discover the use of objects as implements in achieving goals
  Ex. ???

- any restriction of the movements, inhibits child’s ability to learn about an object

- manipulative ability is a rate-limiter to the perception of certain object properties

Can you think of a rate limiter for manipulation?
Categorizing Reaching

Phase I Reaching (Bower, 1977)
- 4 – 6 mos.
  - reach and grasp occur at the same time
  - random and repeated grasping
  - one handed reach
  - **visually initiated**
  - not capable of correction error during the reach
  - use vision to guide grasping

Phase II Reaching
- 6 – 7 mos.
- reach…..then grasp
- can demonstrate two handed reach
- **visually guided** reaching
- use tactile sensation to guide grasping

However…..
Clifton, Muir, Ashmead & Clarkson (1993)

**Method**
- reach in dark to glowing object
- reach in dark to sounding object
- reach in dark to object that sounded and glowed
- reach in light

**Results**
- ???
Another Categorization of Reaching

3 Basic Methods of Reaching (Halverson, 1931)

1. Backhand sweeping toward object
   - does not get object

2. Sweeping or scooping approach
   - indirect, circuitous

3. Controlled reach

What general developmental principle is this an example of?

- 4 mos. reach with shoulder and elbow
- 5 – 6 mos. use wrist, hand and finger control
- 9 mos. use thumb to oppose one finger

Answer:
Prehension
- act of grasping
- develops between 1 mos. – 13 mos.
- Ex. ???

Involves 4 Steps (Halverson, 1931):
1. Object is visually located
2. Object is reached
3. Object is grasped
4. Object is released

Releasing
- 9 mos. drop object
- must relax the muscles in arm
- 18 mos. accurate release
- related to ability to anticipate the weight of an object and regulate force
- Ex. ???
Bimanual Control
- movement of the two arms toward an object
- Ex. ???

- depends on size, weight, and shape of object
- Ex. ???

Complementary
- 8 mos. manipulate object cooperatively with both hands
- Ex. ???

Symmetrical
- 2 mos. extend and raise arms above head
- Ex. ???

Development proceeds:
- 4 mos. clap at body midline
- 4.5 mos. reach with both hands, 1st grasp object
- 5 mos. unimanual reaching
- 7 mos. simultaneous bimanual reaching
- 12 mos. bang two objects together

This is an example of what kind of development?
Bimanual Coordination …… My Research

Symmetrical (In-phase)
- mirroring movements
- both hands move clockwise or counterclockwise at the same time
Ex. ???

Asymmetrical (Anti-phase)
- similar movements
- both hands move to the left together and right together
Ex. ???

Early Childhood
- inconsistent strategies 4 yr. – 8 yr.
- Why?
  - attention
  - speed
  - vision
Reflexes

- involuntary response to a particular stimulus
- occurs below the level of the higher brain centers
- typically do not last longer than 1 yr.

Ex. ???

Importance

- protect us from injury
- critical for human survival
- beginnings to more complex, voluntary movements
- important in diagnosing infant health and neurological maturation
Types of Reflexes

1. Lifespan reflexes
   Ex. ???

2. Primitive Reflexes
   - reflexes used for protection
   - present in all normal newborns
   - birth – 6 mos.
   Ex. ???

What do these two have in common?
   1. Sucking reflex
   2. Search/rooting reflex

3. Postural Reflexes
   - basis for future movement
   - initiated by higher brain centers
   Ex. ???

Stereotypies
   - rhythmical, patterned, movements
   - not learned by imitation
   - most common in legs and feet
   Ex. ???
Object-Control Skills (Read in textbook)

Throwing
pp. 283-295

One-handed catching
pp. 300 - 301

Bouncing
pp. 307 - 308

Striking
pp. 305 – 307

Kicking
pp. 308 - 314
The Development of Locomotion

Prewalking
- require hands, low to ground, slow
- Ex. ???
-
- Upright bipedal locomotion with support

Why do infants want to walk?

Why is it hard for infants to walk?
Walking is a complex task for infants.

Walking involves:
1. Balance
2. Strength
3. Coordination - within the leg
   - between the legs

**Gait Cycle**

1. **Swing phase**
   - begins when any part of foot leaves surface
   - ends when any part of foot reconnects with surface

2. **Support phase**
   - time spent in contact with surface

3. **Flight phase**
   - an airborne phase present in running
Characteristics of Early Walking

Compensations for inadequate balance:
1. Wide base of support
2. Hyper-rotation of toes
3. Larger lateral sway
4. Hyper-flexion of knees
5. Arms in high guard
6. Shorter swing phase
7. Longer double support phase

Experiments:
- submerged infants in water,
  ↑ rate and amplitude of stepping

- supported infants are able to walk

Clark & Phillips (1992)
- added weights to legs, more mature walking pattern
Characteristics of Early Walking

**Compensations for inadequate strength:**
1. Flat foot contact
2. Shorter swing phase
3. Rigid arms

**Experiments:**
- Sutherland, Olshen, Cooper, & Woo (1980) - weak ankle plantar-flexor leg muscles
- Thelen & Ulrich (1991) - treadmill provides forward propulsion
- Bril & BreniΠre (1992) - negative vertical acceleration
- Thelen, Fisher, & Ridley-Johnson (1984) - add weights - step rate and amplitude ↓
- Woollacott & Sveistrup (1994) - EMG recordings demonstrate high stiffness
Characteristics of Early Walking

Indications of inadequate coordination - Intralimb:
1. Stiff and small joint movements
2. No extension - flexion - extension of support leg
3. Use few muscles

Experiments:
Thelen & Cooke (1987)
- initially co-contract many muscles and joints

Sutherland, Olshen, Cooper, & Woo (1980)
- learn to sequence muscles and joints correctly

Woollacott, Debu, & Mowatt (1987)
- inappropriate muscles and sequencing
- only use lower muscles
Characteristics of Early Walking

Indications of inadequate coordination - Interlimb:

1. Not perfectly alternating steps
2. Arms not coordinated with steps

Experiments:
Whitall & Clark (1994)
- 35 - 65 % phasing, instead of 50 %

Thelen & Ulrich (1987)
- less variability in leg relationship on motorized treadmill
- can maintain 2:1 relationship on split-belt treadmill
Challenges of Advanced Locomotion

1. **Jump**
   - more leg strength
   - harder landing forces
   - different coordination between arms & legs

2. **Hop**
   - more strength required
   - more balance required on one leg
   - shift of center of gravity
   - difficult coordination between arms & legs

3. **Leap**
   - difficult landing balance

3. **Gallop**
   - different relationship between arms & legs
   - different base of support

4. **Slide**
   - move in different direction from body position

5. **Skipping**
   - combine hop and step on same leg
   - alternation of leading leg
Sensitive/Critical Period

- A span of time during which a developing organism is particularly susceptible to the influence of an event, stimulus, or mitigating factor

Ex. ???

The environment in which a child is placed can facilitate or delay motor development.

Stimulation  Ex. ???

Deprivation  Ex. ???
Stimulated Environments
  - programs to optimize early motor development

No Programming
  - does not emphasize practice of specific future motor skills

Ex. ???

Programming
  - parent takes an active roll in moving baby

Ex. ???
Disadvantages
- no research that indicates any long-term benefit to normal infants.
- Young children more susceptible to injury
- More stimulation is not always better
- Harmful if type and intensity are not individualized

Advice
- create a stimulating home environment that may facilitate the child’s natural development
- provide a safe, nurturing, and minimally structured play environment for infant
Ex. ???
Experiments:


Methods:
- deliberately facilitate motor skills
Ex. ???

Results:
- achieve 1 mos. Earlier than American infants
- But achieve prone skills later
Ex. ???

Conclusion: ???

Walker Use - Crouchman (1986)

Methods:
- compared infants who used walkers and infants who did not

Results: ???

♦ Take Home Point

- investigated directly the effects of early stimulation on motor development

Method:

21 days – 22 mos.

- **Johnny** toys and considerable stimulation, practice experience in a variety of movement activities
- **Jimmy** few toys and minimal motor stimulation
- At certain periods tested on selected movement activities

Results: ???

**Readiness**
- individual is prepared, or ready to acquire a particular behavior
- sufficient information and ability have accumulated
- the necessary physical characteristics have been attained
- the child is motivated
Ex. ???

♦ Take Home Point
Deprived Environments
- less than optimal environments which affect normal development

Experiments:
Hopi Indians’ Cradleboards  - Dennis (1930)
Methods:
- 1 mos. to 1 yr. swaddled and tied to a board
- arms were extended at sides allowing only a slight bend

Results: ???

Deprivation Dwarfism
- emotional disturbance that is conveyed by hormones to centers that control the secretion of the growth hormone

Situations:
- long-term hospitalization results in listless, apathy, and depression

Results:
- fail to gain wt., develop respiratory infections, and fever
Orphan Study
Method:
- 1 stern and uncaring, 1 cheerful and loving

Results:
???

Del and Rey - Dennis (1935)

Method:
- 2 fraternal twins from 36 days until 14 mos.
- Left alone, lying on their backs

Intervention:
- at 8 mos. prone on floor for 5-30 min/day

Results:
???

♦ Take Home Point

Other Ex.
Anna
Victor
Catch-Up

- unusual power a human displays to stabilize and return to a predetermined behavior or growth pattern

- evidence that the human body is capable of acquiring growth more rapidly than normal during a period of recovery

- can occur intellectually, socially, and motorically

- degree of recovery depends on the severity, length, and time of deprivation

- may never realize their genetic potential

Ex. ???
Motor Development Revisited

- the study of the changes in motor behavior over the lifespan, the processes that underlie these changes, and the factors that affect them

However....
- not practically applied

- ignorance about motor changes in adulthood

♦ Take Home Point
“One of the most pervasive manifestations for aging is slowing responses”

How do we measure this?

**Reaction Time**
- interval from presentation of an unanticipated stimulus until the beginning of the response
  Ex. ???

**Movement Time**
- interval from the initiation of the movement until its termination
  Ex. ???

** Both decline systematically in adulthood**
**Speed-Accuracy Trade-off**

- Older sacrifice speed for accuracy

Ex. ???

**Why?**  - more cautious
  - inability to suppress monitoring during their movement

**Experiment: Goggin & Stelmach (1990)**

**Method:**
- used qualitative measures
- age 77 yrs

**Results:**
???

** Slowing increases as task complexity increases**
Ex. ???

♦ **Take Home Point**
Reaching and Grasping in Older Adulthood

Experiment: Bennett & Castiello (1994)

Method:
- 12 older (M = 64.8), 12 control
- reach and lift a small (.7 cm), large (8 cm) cylinder

Results: ???
1. ???
2. ???
3. ???
4. ???

Grip Strength - ???
Balance and Postural Sway

- 70% of deaths are due to falls in those 65 or older!!
- falls are due to a loss of balance
- avoid physical activity because of fear of falling
- enhanced by pathological conditions
- 80 +, exhibit postural control like 6 – 9 yrs.
- partly due to declining sensory systems
  Ex. ???

- balance becomes automatic in childhood
  But reverses and requires conscious effort in late adulthood

- 40% of falls due to inattention
Experiment: Stelmach, Zelaznik, & Lowe (1990)
Method:
- balance and a secondary task
  1. math verification task
  2. squeeze task
  3. swing arms
  4. swing arms plus math task
  5. swing arms plus squeeze task

Results: ???
- 
- 
- 

Experiment: Roberts (1989)
Method:
- walking 30 min. at 60 – 70% of max. HR, 3x/week for 6 weeks

Results: ???
- 
-
Factors in an Exercise program
1. Reduce physiological regression
2. Safety and security
3. Appropriate instructions
4. Eliminate physiological and emotional stress
5. Feeling of comfort and belonging
6. Deliver positive reinforcement
7. Ensure proper level of arousal
8. Inform benefits of exercise and learning
9. Adequate lighting and temperature
10. Teach where to focus attention
11. Teach what sensations accompany the Movement
12. Attach to an old memory
13. Allow more time
14. Slower more constant pace
Activities of Daily Living (ADL)  
Ex. ???

**Compensatory Strategies**  
- pay more attention  
- pace exercise  
- anticipation of movement  
- sacrifice speed for accuracy  
- greater expectations

**Effect of Practice**  
- older adults to benefit from practice  
- practice at a particular task improves that task  
- mental practice improves balance  
- balance training improves balance
Parkinson’s Disease Fact Sheet

What is Parkinson’s disease?
Parkinson’s disease is a serious neurological illness named after Dr. James Parkinson, a London physician, who first described it as the 'shaking palsy' in 1817. Parkinson’s is a slowly progressive disease that affects a group of cells in the basal ganglia; these cells gradually degenerate and die. Their loss produces a reduction in the neurotransmitter dopamine. Decreased levels of dopamine results in the motor deficits associated with Parkinson’s disease.

Cardinal symptoms of Parkinson’s disease
1. Tremor –
   Ex. ???

2. Rigidity –
   Ex. ???

3. Bradykinesia –
   Ex. ???

4. Akinesia –
   Ex. ???

5. Postural dysfunction –
   Ex. ???
Other symptoms of Parkinson’s disease
‘Freezing’
Ex. ???

Loss of voice power
Ex. ???

Decreased facial expression
Ex. ???

Micrographia
Ex. ???

Locomotion
- low walking velocity
- small stride length
- shuffling steps
- reduced or absent arm swing
- rigidity in trunk movements
- problems in gait initiation
- problems in gait switching
**Who is afflicted?**
Approximately 1.5 million Americans (1 out of every 100 people over the age of 60). It has become one of the most common ailments in the United States.

**Can you name people with Parkinson’s disease?**
- 
- 
- 
- 
- 
- 

**What causes Parkinson’s disease?**
- unknown cause

**Is there a cure for Parkinson’s disease?**
- not yet
- there are surgical and pharmacological methods to alleviate some of the symptoms
- Dr. George Stelmach directs the Motor Control Laboratory in the Department of ESPE at ASU and Parkinson’s disease research is a main focus.
Perceptual-Motor Development

- the relationship between human movement and perceptions

Ex. ???

Perception

- our ability to receive information through the senses

- not a perception unless perceived
Ex. ???

Is movement important for the optimal development of perceptions?
**Experiment:** Held & Hein (1963)

**Method:**
- raised 2 kittens in complete darkness for 8-12 weeks
- attached kitten’s to carousel
- active kitten, propelled itself around
- passive kitten, glided around due to active kitten
- 3 hours /day

**Results:** ???
- ???
- ???
- ???
- ???

**Conclusion**
???
Experiment: Kermoian & Campos (1988)
- investigated the link between infants’ self-produced locomotion and their perception of spatial relationships by studying the infants’ strategies in searching for objects.

Method:
Tasks
1. retrieving hidden object under 1 cloth
2. retrieving hidden object under 2 cloths
3. retrieving hidden object after 3 second delay

Participants
Prelocomotor infants
Prelocomotor infants with walker experience
Locomotor (creeping) infants

Results: ???
- 
- 
-
Perceptual-Motor Programs
- perceptual-motor abilities are learned
- replace academic activities with movement activities to improve problem solving
- activity improves depth perception which eventually may improve reading

Effectiveness of Perceptual-Motor Programs
- average length 19 weeks
- negligible improvement
- extra time, energy, and money
- many do not incorporate academic concepts into the movement activity
- may improve perceptual-motor abilities but less likely to enhance academic achievement

Is all movement perceptual-motor?
Five Common Perceptual-Motor Concepts:
1. Balance
   - postural control
   - ability to maintain equilibrium by keeping the center of body mass over its base of support
   - affected by a multitude of variables
   Ex. ???

Static balance
Ex. ???

Dynamic balance
Ex. ???

Experiment: Deoreo (1975)
Method:
- 3-5 yr. olds walk across beams of varying widths

Results:
• youngest shuffle step
• older alternate stride
• 25% of 3 yr. not make it across the beam
• narrower beam elicits a more immature pattern
Five Common Perceptual-Motor Concepts:

2. Spatial Awareness
   - the understanding of the external spaces surrounding an individual
   - the individual’s ability to function motorically in and through that space
   Ex. ???

Egocentric Localization
   - immature and limited
   - most aspects of surroundings are noted in reference to themselves
   Ex. ???

Object Localization
   - move advanced
   - referencing objects relative to other objects
   Ex. ???
Spatial Awareness is facilitated through involvement in movement activity.

**Improves movement activity**
Ex. ???

**Improves academic activity**
Ex. ???
Five Common Perceptual-Motor Concepts:

3. Temporal Awareness
- the understanding of time relationships

Coincidence-anticipation timing
- ability to predict the arrival of a moving object to a certain point in space and to coordinate a movement with that arrival
- children are slower and less accurate
Ex. ???

Coordination of part’s of own body
Ex. ???
Five Common Perceptual-Motor Concepts:

4. Body Awareness

- ability to know and understand names and functions of various body parts
- ability to understand the body’s potential in movement performance
- how to produce various movements
- important to optimal movement performance

Ex. ???
Five Common Perceptual-Motor Concepts:

5. Directional Awareness
- the understanding of concepts of up, down, front, back etc.

   Laterality
   - understanding of various directional concepts
   Ex. ???

   Directionality
   - the application of that information
   - mature by 6 yr.
   Ex. ???

Does it improve with movement activities?

Does it improve academic abilities?

*** First Exam Material Ends here!! ***
Motor Control

- attempts to understand what and how movement is being controlled
Ex. ???

Motor Skill

- tasks that have been acquired
Ex. ???
Skill Classification

Why?

♦ Different types of practice are necessary for different types of skills

♦ Motor Skills can be conceptualized in two ways:
  1. A Task Perspective
  2. A Performance Proficiency Perspective
Skill Classification: 
A Task Perspective

- determining prominent characteristics that can be used to distinguish one task from another

1. Task Organization

Discrete vs. Continuous vs. Serial

Discrete Skill - defined beginning and end
- usually brief in duration
Ex. ???

Continuous Skill - no defined beginning or end
- usually lasts many minutes
Ex. ???

Serial skill – a group of discrete skills strung together
- order of elements is critical to performance
Ex. ???
2. Relative Importance of Motor and Cognitive Elements

Motor vs. Cognitive

**Motor Skills** – the determinant of success is the quality of the movement i.e. ‘How’ to do it

Ex. ???

**Cognitive Skills** – the decisions about which movement to make are critical i.e. ‘What’ to do

Ex. ???
3. Level of Environmental Predictability

**Open Vs. Closed**

**Open Skills** - the environment is unpredictable during the action

Ex. ????

**Closed Skills** - the environment is predictable

Ex. ????

Semi-predictable Environment

Ex. ????
Skill Classification:
Performance Proficiency Perspective

- features that distinguish higher-skilled performers from lower-skilled ones

1. Maximum Certainty
- meet goal predictably

Ex. ???

2. Minimum Energy
- elimination of unnecessary movement

Ex. ???

3. Minimum Movement Time
- increased speed

Ex. ???
Problem-Based Learning
- an approach to learning that presumes that the key to understanding is the ability to ask the right questions

Why?
- solutions to learning motor skills depends on a number of things

Three Important Questions

1. Who?
   - What are some characteristics of the person
   Ex. ???

2. What?
   - What are important features of the task
   Ex. ???

3. Where?
   - Where will task take place
Information-Processing Approach:
To Motor Performance and Learning

♦ Human is a processor of information

3 Information Processing Stages

1. Stimulus identification
   - has a stimulus been detected?
   - what is it telling me?

Ex. ???

2. Response selection
   - what movement do I make?

Ex. ???

3. Response programming
   - retrieve and organize a motor program that will control the movement

Ex. ???
Reaction time (RT)

- measures the speed of information processing
- time between stimulus identification and beginning of response
Ex. ???

Factors Influencing Reaction Time

1. Number of Stimulus-Response alternatives
   - detect stimulus
   - **select response**
   - initiate response

Hick’s Law
   - the time to select a response increase with greater number of choices
   - this does not occur linearly

Ex. ???
2. Stimulus-Response (S-R) Compatibility

- the extent in which the stimulus and response are connected in a ‘natural way’

- increasing S-R compatibility, decreases RT

- difficulty in response-selection stage

Ex. ???
3. Amount of Practice

- highly practiced performers can overcome the disadvantages of low S-R compatibility

- larger amount of practice, the shorter the RT

- high S-R compatibility practice, decreases RT most
4. Anticipation to Minimize Delays

- one way to cope with RT is to anticipate a response

- become efficient at detecting stimuli, where they will appear, and when they will occur

Costs of Anticipating
Ex. ???

Benefits of Anticipating
Ex. ???
Control Systems

1. Closed-loop (conscious)

   - control of movement involving feedback and error detection and correction

Loop completed from:
1. Executive (decisions) to
2. Effector (carries out decisions) to
3. Feedback (information about state of system) to
4. Comparator (error detection) relays error back to
5. Executive
Limitations of Closed-Loop Control

- information processing stages require considerable time and attention
- therefore, closed-loop control is slow
- feedback registered after 150-200 ms, time to change, new feedback 150-200 ms…….
- 3-4 compensations/sec

What type of tasks benefit most from closed-loop control?
Slater-Hammel Experiment (1960)

Method:
- held a finger on a key
- clock hand on timer rotated 1 full revolution /sec
- lift finger from key to stop clock hand at 8 (800 ms)
- on unpredictable trials, the clock hand would stop before it reached the ‘8’
- then must not lift finger

Results: ???
- 
- 
- 

♦ Take Home Point

Why is this important?
Control Systems

2. Compensations (unconscious closed-loop control)
   - reflexes, involuntary, rapid responses to stimuli

4 Kinds of Compensations

1. M1 Response (Monosynaptic Reflex)
   - occurs 30 – 50 ms after added load
   - brief, limb still moving down
   - short distance to travel
   Ex. ???

2. M2 Response (Functional stretch/long loop reflex)
   - occurs 50 – 80 ms after added load
   - larger EMG force
   - longer duration
   - contributes more to movement compensation
   Ex. ???

3. Triggered Reaction
   - occurs 80-120 ms after added load
   - can be learned
   Ex. ???

4. Voluntary Reaction Time Response (M3 Response)
   - 3rd burst of EMG
   - powerful and sustained
   - modified by instructions, anticipation, etc.
   - requires attention
   Ex. ???
Sensory Information

1. Exteroceptive Information
   - sensory information from primarily outside the body

   Ex. ???
   1.
   2.

   Important for what movements?

2. Proprioceptive Information (kinesthesia)
   - sensory information from within the body

   Ex. ???
   1.
   2.
   3.
   4.

   Important for what movements?
2 Visual Systems for Motor Control

1. Focal Vision

- specialized for conscious identification of objects in the center of visual field
- object identification
- degraded in low light
- sometimes not enough time to use
- What is it?

Ex. ???
2. Ambient Vision

- specialized for movement control

- central and peripheral

- unconscious

- detect motion and position of elements in environment

- Where is it? Where am I relative to it?

Ex. ???
Optical Flow

– the tendency for patterns of light rays from the environment to flow over the retina allowing perception of motion, position, and timing

Information about:

• Balance

• Velocity of movement

• Direction of movement

• Relative motion

• Time until contact
Control Systems

3. Open-loop Control

- control of movement in which instructions for the movement are determined in advance
- no feedback used during movement

Motor Program
– the detailed instructions for a movement at the executive level

- initiated ‘all-or-none’, action ‘takes care of itself’

Ex. ???

What is different from closed-loop control?
Limitations

- does not control moment-to-moment contractions and adjustments

- not enough time to process feedback

What type of tasks benefit most from open-loop control?
Robertson et al. (1994)

- investigated closed-loop vs. open-loop control

Subjects: Expert and novice gymnasts

Task: Walking across a balance beam

Method: Manipulated vision (feedback)

Conclusions:

1.

2.

3.

♦ Take Home Point
Motor Program Theory

How can we combine so many movements so quickly?

- known as the degrees of freedom problem

Ex. ???
**Motor Program**
- a set of muscle commands that are organized in advance and run off without much feedback

- analogous to a computer program

- specific instructions to muscles
  - which muscles
  - what order
  - what timing and sequencing
  - what duration

**Phonograph (CD) Analogy**
CD defines which sounds occur and in what order, duration, and timing
Evidence for Motor Programs

1. Reaction time increases as the complexity of the movement increases

   RT is longer because more time is required to organize the actions

Complexity can be increased by:
- Adding elements to an action
  Ex. ???

- Involvement of more limbs
  Ex. ???

- Longer duration skills
  Ex. ???
Experiment: Henry & Rogers (1960)

Method:
- respond as quickly as possible to a stimulus

3 Different Responses
1. Lift the finger
2. Lift finger, reach and grasp suspended ball
3. Lift finger, hit several targets in different directions

Note Stages of Information Processing:
Same stimulus (stimulus identification)
One response (response selection)
Different length of programs (response programming)

Results: ???

♦ Take Home Point
Evidence for Motor Programs

2. Deafferentation Experiments

Deafferentiation
- cutting sensory nerves so the CNS does not receive sensory information

What are we capable of when deprived of feedback from the limbs?

Experiment: Taub & Berman (1968)
Method:
- deafferented upper limbs of monkeys

Results: ???
What does this tell us?

- sensory information is not critical for movement production

- feedback-based theories cannot account for the monkeys’ movement capabilities

♦ Take Home Point
Evidence for Motor Programs

3. Effects of Mechanically Blocking a Limb

Experiment: Wadman, Denier van der Gon, Gueze, & Mol (1979)

Method:
- examined muscle activity during quick limb movement
- on some trials the movement was unexpectedly stopped by the experimenter

Results: ???

♦ Take Home Point
Limitations to Motor Program Theory

1. Novelty Problem
How is a novel movement produced?

Isn’t every movement novel in some way?

2. Storage Problem
How do we store the countless number of MP?
Solution: Generalized Motor Program

- a stored pattern that can be modulated slightly

- allows the movement to be adjusted to meet altered environmental demands

Ex. ???
Evidence for Generalized Motor Program

1. Variations in Movement Time

Experiment: Armstrong (1970)

Method:
- produced a pattern of movement (4 direction-reversals) at the elbow joint

Results: ???

♦ Take Home Point
2. Variations in Movement Amplitude

Experiment: Hollerbach (1978)
Method:
- write words in different sizes

Results: ???

Sport Example ???

♦ Take Home Point
3. Variations in Limb and Muscles Used

Experiment: Raibert (1977)
Method:
- write a sentence with right hand, right arm, left hand, mouth, & foot

Result: ???

♦ Take Home Point
Summary of Generalized Motor Programs

Parameters
- the modifiable components, surface features

Ex. ???

Parameter Values
- values or adjustments chosen to meet environmental demands

Ex. ???

Ex. Throwing motor program
Parameters modified:
**Speed** - professional pitch
- pitch to my nephew

**Muscles** - baseball throw
- shot put

**Amplitude** - throw from 2\textsuperscript{nd} base to 1\textsuperscript{st}
- throw from outfield to infield
Attention
- capacity to process information

Can be directed:
1. Externally
   Ex. ???

2. Internally
   Ex. ???

3. Mentally
   Ex. ???
Four Characteristics of Attention

1. Attention is **limited**
   Ex. ???

2. Attention is **serial**
   Ex. ???

3. Attention is **effortful**
   Ex. ???

4. Attention is **selective**
   Ex. ???
Information Processing and Attention

1. Stimulus Identification: Parallel Processing
   - 2 or more pieces of information can be processed together without interfering

   Ex. ???

1. Response Selection:
   Controlled Processing
   - Slow, serial, effortful, attention demanding
   - Affects poorly learned or novel tasks

   Ex. ???

Automatic Processing
   - Fast, parallel, involuntary, not attention demanding
   - Affects highly practiced tasks

   Ex. ???
3. Response Programming: **Serial Processing**

**Psychological Refractory Period**
- the delay in responding to the 2\textsuperscript{nd} of 2 closely spaced stimuli

**Experiment:**
- **Task:** Respond to a tone by lifting right hand
  - Respond to a light by lifting left hand

  **Interstimulus Interval:**
  - Tone and light separated by 0 – 300 ms

**Results:** ????

**Explanation:** ????
How do you measure Attention?
- interference is a measure of attention
  Ex. ???

When do the hands interfere with each other?

1. Different timing
   Ex. ???

2. Different muscles used
   Ex. ???

3. Different spatial pattern
   Ex. ???

♦ Take Home Point
How come some people can perform different tasks?

Ex. ???

- They learn to **control the hands separately**:  
  - one hand is under automatic processing
  - the other hand is under controlled processing

  OR

- They learn a **new program that controls both hands** at the same time
Grouping
- occurs when both stimulus occur within 40 ms - both stimuli are detected as a single event
- both responses occur simultaneously

Ex. ???

Output Chunking
- producing several movements as a single unit
- organized in the response programming stage
- run off under control of motor program

Ex. ???
Three Memory Systems

1. Short-Term Sensory Store (STSS)
   - most peripheral, sensory
   - stores processing of stimulus identification
   - stores for max. \( \frac{1}{4} \) sec (250 ms)
   - no conscious involvement
   Ex. ???

2. Short-Term Memory (STM)
   - not all sensory information reaches consciousness
   - selective attention selects info. for further processing
   - final selection based on relevance to the task
   - 7 ± 2 chunks of items remembered
   - lasts only 30 sec. after no attention is directed
   Ex. ???

3. Long-Term Memory (LTM)
   - contains well-learned information collected over a lifetime
   - limitless in capacity
   - abstract coding
   - stored by controlled processing, effortful
   Ex. ???

What type of tasks are remembered best?
Individual Differences
- the study of people’s differences
- stable, enduring tendencies for individuals to be different from each other in performance
- must be stable from attempt to attempt

Ex. ???

Abilities
- largely inherited capabilities that underlies skilled performance
- less dependent on practice

Ex. ???

Capabilities
- characteristics that are subject to change with practice

Skill
- proficiency at a particular task
- modified by practice
- countless in number
- depend on several abilities

Ex. ???
Examples of some proposed Abilities
Fleishman (1964)

Method:
- discover what underlying abilities might be

Result:
- limited # (20 – 50)
  Ex. RT, MT
  Response Orientation
  Finger/manual dexterity
  Response Integration
  Dynamic strength
  Explosive strength
  Gross body coordination
  Stamina
  Etc.
Things to think about....

How can it be that some people are better at some skills?

Is expertise simply due to practice?

Is there a general intelligence?
Ex. ???

Is there a general motor ability
Ex. ???
Experiment: General

Method:
- many people performed many different tasks that were assumed to measure general motor ability

Results:
- if tasks have same ability, then performance on each task should be high -> high correlations

Experiment: Drowatzky & Zuccato (1967)
Method:
- 6 balance tests
  1. stork stand
  2. diver’s stand
  3. stick stand
  4. sideward stand
  5. bass stand
  6. balance stand

Result: Highest correlation = .31 (9.6% in common)

What does that mean?
Henry’s Specificity Hypothesis (1968)

Concepts:
1. Movement behaviors are based on a very large # of abilities
   Ex. ???

2. Abilities are independent/specific
   Ex. ???

3. One skill is supported by many abilities
   Ex. ???

Experiment: Henry (1968)

Method:
- basketball players, gymnasts, rifle shooters and non-athletic groups all performed the same laboratory motor skill task

Results:

Support for general motor abilities
Ex. ???

Support for specific motor abilities
Ex. ???
Experiment: Bachman (1961)
- balance on Bachman ladder
- balance on stabilometer

Results: ???

Experiment: Keele & Ivry (1987)
- there are certain fundamental abilities that can be shared by a variety of motor tasks

Ex. Timing ability  - effectors
    - systems
    Force control
    Movement rate
Robertson et al. (1999)

Experiment 1: If you are a good timer at one rate, are you a good timer at another rate?

Task: Tapping at 400 ms
     Tapping at 800 ms

Results: ???
Robertson et al. (1999)

**Experiment 2:** If you are a good timer at one task at 800 ms, are you a good timer at another task at 800 ms?

**Task:** Tapping at 800 ms
Drawing circles and lines at 800 ms

**Results:** ???

**Experiment 3:** Are drawing tasks related?

**Task:** Drawing circles and lines

**Results:** ???

**Take Home Point**
Why are individual differences important?

- interest in future capabilities (prediction)
  Ex. ???

- direct people to activities they are best suited for (selection)
  Ex. ???

How is this done?

- estimate strengths of abilities
- based on importance to task
  Ex. ???

*** Exam 2 Material Ends Here!! ***
EPE 345
Motor and Developmental Learning
Midterm Evaluation

This is an opportunity for you to give me feedback about this course. Please provide suggestions/comments that would help me improve the course so that you may learn this material better.

1. What in particular do you like MOST about the course and/or the instructor?

2. What in particular do you like LEAST about the course and/or instructor?
Motor Learning
- a set of internal process associated with practice or experience leading to a relatively permanent gain in performance capability

- Occurs through practice or experience
  - not growth and maturation

- Not directly observable
  - increased use of automatic processes
  - improvements in response selection
  - building more effective MP
  - more accurate reference of correctness
  - must be inferred from changes in performance
Observable Products of Learning

1. Knowledge of concepts
   Ex. ???

2. Control and coordination
   Ex. ???

3. Muscles used
   Ex. ???

4. Movement efficiency
   Ex. ???

5. Attention
   Ex. ???

6. Error detection and correction
   Ex. ???

- **Leads to relatively permanent changes**
  - not easily reversible
  - available at some future time
How is motor learning measured?

1. Outcome Measures
   - observations that indicate some aspect of the end result of performance

   Ex. ???

2. Process Measures
   - observations about the quality of movement production

   Ex. ????

3. Error Measures
   **Constant Error**
   - average deviation of the results of several movement attempts

   **Variable Error**
   - average constant error of the movements
Performance Curves

- a measure of performance is plotted across time practiced (trials)

- most often group or trial averages are plotted

- direction depends on what measure of performance is used
  Ex. ???

- changes are rapid at the beginning and more gradual later
  This is called the

- amount of improvement depends on difficulty of task
Limitations to Performance Curves

- chart performance not learning
- averaging performances will mask individual differences
- not able to see changes within individuals
- changes can be due to temporary factors
  Ex. ????
Solutions to Measuring Learning

1. Retention Task
   - same task 5 min later, 24 hours later, days later, etc.
   - Ex. ???

2. Transfer Task
   - test performance on a similar task
   - amount and direction are influenced by: perceived similarity degree to which the two skills require the same type of cognitive processing
   - Ex. ???
Types of Transfer:

**Positive Transfer**
- gain in proficiency in one task as a result of practice in another task
Ex. ???

**Negative Transfer**
- loss in proficiency in one task as a result of practice in another task
Ex. ???
Types of Transfer:

**Near/Intratask Transfer**
- generalize to different performance conditions
- the new task is relatively similar to the trained task
- **Only the conditions in which the skill is to be performed are altered…the skill is still the same**

Ex. ???

**Far/Intertask Transfer**
- perform a variation of a movement skill just learned
- the new task is quite different from the trained task

Ex. ???
Stages of Learning

Question: Have you ever noticed that people who are skilled in an activity often have trouble teaching it to a beginner?

Why? They do not understand how the beginner approaches the task.

Solution: - Coach/therapist must consider the point of view of the athlete/patient.

- Instruction for learning will depend on the stage of learning a person is in
Three Stage Model of Skill Acquisition
Fitts and Posner (1967)

1. **Verbal-Cognitive Stage**
   - task is completely new
   - many questions: What to do? When to do it? How to do it?
   - verbal and cognitive abilities dominate

2. **Motor Stage**
   - organize more effective movement patterns
   - strengthen motor program
   - consistency gradually increases
   - develop anticipation
   - monitor own feedback

3. **Autonomous Stage**
   - development of automatic actions that do not take attention
   - programming longer movement sequences
   - allow to perform cognitive activities
   - detect errors better
Two Stage Model for Instruction and Rehabilitation Environments
Gentile (1972)

1. **Getting the idea of the movement**
   - learn to organize movement to accomplish the goal
   - learner must identify and selectively attend to relevant conditions

2. **Fixation/Diversification**
   - learner matches the acquired movement pattern to the environment

Ex. Stable environment ???

Varied environment ???

**Comparison of the two theories**

*Similarities*
- 
- 
- 

*Differences*
- 
-
Question: What types of practice produce the most effective learning?

Answer: What?

Who?

Where?
Observational Learning
- the learner acquires the capability for action by observing others
- information is transmitted easily this way
- most beneficial early in learning

This is achieved by:

1. **Modeling**
- a practice procedure where another person demonstrates the correct performance of the skills to be learned

2. **Visual Aids**
Ex. ???
Guidance Techniques
- a procedure used in practice where the learner is physically, verbally or visually directed through the performance to reduce errors

- ensure proper pattern is carried out early in practice
  Ex. ???

- ensure safety in dangerous tasks
  Ex. ???

Take Home Point
How effective is Guided Practice?

**Experiment:** Annett (1959)

**Task:** Produce a given amount of pressure on a hand-operated lever

**Groups:**
- Visual guidance
- No visual guidance

**Results:** ???

**Explanation:**
- the learner relies too strongly on guidance
- guidance modifies the way a task feels
- decision-making is reduced
- no opportunity to experience errors and make corrections
- guided and unguided tasks may be different tasks thus no transfer occurs
Part Practice

- a complex skill is broken down into parts that are practiced separately
- must divide skill into meaningful units
- integrate into the whole skill at a later time
- based on transfer of learning

Three Types of Part Practice

1. Fractionization
   - two or more parts are practiced separately
   - Ex. ?

2. Segmentation/progressive part
   - one part is practiced until it is learned, then second part is added until entire target skill is practiced
   - Ex. ?

3. Simplification
   - the difficulty of some aspect of the target skill is reduced
   - Ex. ?

What type of tasks benefit from part practice?
Mental Practice
- A mental rehearsal procedure in which the learner think through or about cognitive, symbolic or procedural aspects of an action without overt physical practice
- combination of mental and physical practice is best

Mental Imagery
- mental rehearsal in which learning imagines themselves performing a motor skill

How to perform mental Imagery
- done in a quiet place
- imagine the event vividly in color & sound
- image in real time, in sequence
- image success

How does mental practice work?
- facilitates the cognitive-symbolic elements of the skill in early stages of learning
- mentally experiencing consequences
- produces small contractions of the proper musculature
- builds confidence
- produces relaxation
Structuring the Learning Experience

How should we sequence practice at various tasks to maximize learning?

How much rest during practice?

Depends on task.

**Massed practice**
- amount of rest between trial is short relative to trial length
- almost continuous
- most beneficial for discrete tasks
Ex. ???

**Distributed Practice**
- the amount of rest between practice trials is long relative to the trial length
- most beneficial for long duration continuous tasks
Ex. ???
Blocked Practice
- repeatedly rehearse the same task
- Ex. ???

Random Practice
- perform a number of different tasks in no particular order
- Ex. ???

Experiment: Shea & Morgan (1979)

Groups: Blocked practice
    Random practice

Results: ???
**Explanation**

1. **Elaboration Hypothesis**  
   **More meaningful and distinctive learning**  
   **Random** - altering tasks made the tasks more distinctive/different  
   - associate with something in LTM  
   - more actively engaged  
   **Blocked** - do a set of trials almost automatically  
   - repeating a task does not require that task differences will be noted

   • Increased meaningfulness and distinctiveness produces more durable, or less confusing memories

2. **Forgetting/Spacing Hypothesis**  
   **Random** - when do a 2\textsuperscript{nd} task, forget 1\textsuperscript{st} task  
   - when do 1\textsuperscript{st} task again, must generate a new solution  
   **Blocked** - do 1\textsuperscript{st} task many times so just repeat action

   • Solution generation or retrieval practice is important for learning b/c it forces retrieval from LTM
Practical Implications:

• Repetition is most commonly used but is not the best practice situation for learning

• Blocked practice gives a false sense of skill

• When context is variable, thus more variable practice will be more beneficial
  Ex. ???
Is random practice always better?

Consider stage of learning
  - in the beginning stage of learning, blocked practice may be slightly more effective until the learner performs a rough approximation
  - Ex. ???

Consider the task
  - darts is a closed-loop task with very little variation
  - Ex. ???
Types of Practice
1. Constant Practice
   - only a single variation of a given class of tasks is practiced
   
   Ex. ???

2. Variable Practice
   - practice of many variations of a class of actions
   
   Ex. ???

Experiment

Groups: Constant Practice
        Variable Practice

Results: ???

Take Home Point
Schema Learning

- learner acquires a set of rules/schema that modulate the parameters of a GMP

- with each variation of a throw, the schema is updated for new tasks, the learner estimates the best parameter based on wide experience
How are random and blocked practice different from variable and constant practice?

• Random and blocked practice are different in their order of practicing any number of tasks

• Variable and constant practice involve skills that are all in a particular class of actions (i.e. throwing a football)

What is the best combination for learning to throw a football?
Benefits of Practice

Automaticity
- information processing is relatively attention free, parallel and fast
- developed around 300 trials (# of trials increases with increasing complexity of task)

Consistent Mapping
- practice with a given stimulus always leads to the same action
- less practice to achieve automaticity
Ex. ???

Varied Mapping
- practice with a given stimulus sometimes leads to one response and sometimes to another
- more practice to achieve automaticity
Ex. ???
Feedback

- the difference between the system and it’s goal

- often meaning augmented or extrinsic feedback in motor learning

- any kind of sensory information about the movement

- information fed back to the performer

Importance

- information is critical for movement planning, anticipation, decision making, parameter selection etc.
Classifying Feedback

1. Intrinsic Feedback

- sensory information that normally occurs with movement (perceived without special methods or devices)

- can come from exteroception or proprioception

Ex. ???

2. Extrinsic Feedback

- sensory information provided by an outside source

- augmented natural feedback

- coach/instructor controls this information

- information from the measured performance outcome conveyed by artificial means

Ex. ???
Knowledge of Results (KR)

- Important category of extrinsic feedback

- Augmented, post-response, verbalizable

- Information about success in meeting the movement goal

- Usually verbal information about the success of an action (often redundant with intrinsic feedback)

Ex. Redundant ???

Not redundant ???

• KR can be given or not, given at different times, given in different forms etc.

• Experiments have been conducted to determine the effects of different KR on performance
Knowledge of Performance

- augmented feedback that provides information
- about the quality of the movement
- kinematic feedback
- does not convey information about success

Ex. ???
Properties of Extrinsic Feedback

1. Motivational properties
   - produces motivation or energizes the learner
   - effective during fatigue, boredom
   - effective if public
   Ex. ???

2. Reinforcing properties
   - supplies reinforcement for correct and incorrect actions (Thorndike’s Law of Effect, 1927)
   - Improved chance that this action will be repeated
   - Strengthening the associations between a given stimulus and the correct response and weakening incorrect responses
   Ex. ???

3. Informational Properties
   - provides information about errors as a basis for corrections
   - provides direction for modifying future performance
   Ex. ???

4. Dependency Producing Properties
   - creates a dependency, leading to problems at feedback withdrawal
   - when feedback is given frequently, the learner uses it rather than some internally generated information
Methods to Reduce Dependency:

1. Faded Feedback
   - relative frequency is high in early practice and diminishes later in practice

2. Bandwidth Feedback
   - feedback is delivered only if errors occur outside a range of correctness
   - faded feedback is a by-product

3. Summary KR
   - information is presented only after a set of trials has been completed
   - feedback is withheld for a set of trials (5 – 20)
   - feedback for every trial is given but is delayed
   - length of summary varies with task complexity

4. Average KR
   - based on the average of several trials rather than on any one of them
   - filter out variability and detect learner’s typical pattern
   - more reliable information about what to change and how much to change it

Explanation
- prevents dependency b/c several trials with no KR
- encourages learners to analyze their own response-produced feedback and detect own errors
Determining What Information to Give:

1. **Match feedback to what is controlled**
   - feedback about motor program variables
     Ex. ???
   - GMP parameters
     Ex. ???
   ♦ Give program feedback before parameter feedback

2. **Type of feedback**
   **Descriptive**
   - describes the errors made during performance
     Ex. ???

   **Prescriptive**
   - describes the errors and suggests something the learner might do to correct
     Ex. ???

3. **Amount of feedback**
   - give one source of feedback which should be the most fundamental
   - learner is limited by information processing and memory capabilities
     Ex. ???

4. **Precision of feedback**
   - how close the reported feedback information is to the actual performance value
   - depends on stage of learning
Determining How Often to Give Feedback

Thorndike’s Perspective
- learning occurs through strengthening associations
- increased KR, increased strengthening
- KR immediate, precise, frequent, informationally rich

Absolute Frequency
- the actual # of feedback presentations in a series of trials
  Ex. ???

Relative Frequency
- the proportion of trials during practice on which feedback is given (i.e. absolute freq/ # trials)
- decreased relative frequency enhances learning
- on blank trials allow information processing activities to occur
  Ex. ???
Feedback Delays

Inter-trial Interval - time between trials

1. Feedback delay - end of a trial until feedback is Presented
   - Ex. ???

2. Post-feedback delay - interval from feedback until the next trial
   - Ex. ???

Is instantaneous feedback best for learning?

Why?
What to do in the feedback delay?

• Intervening activity of a different task
  Ex. ???

• Intervening activity of the same task
  Ex. ???

Which is best?
Post-feedback Delay

- the learner tries to generate another movement based on the KR

How much time is needed?
- longer than 5 sec. b/c time is required for processing this information
- more time is needed in more complex tasks

However, post-feedback delay is not very influential on learning.

*** Final Exam Material Ends Here!!**