Neurological Rehabilitation Principles

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MARCH 20, 2015

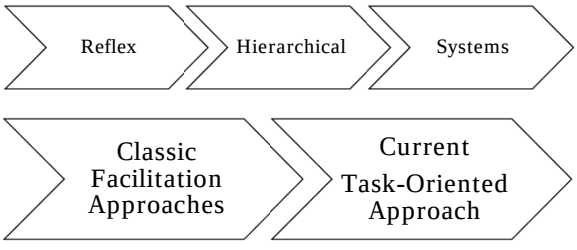
OBJECTIVES

- Understand basic neurological principles including Rood, Brunnstrom, PNF, and NDT.
- Review neuroplasticity and its impact on patient recovery.
- Understand motor control theories.
- Aerobic exercise and its role in maximizing neuroplasticity.
- Be exposed to new rehabilitation interventions supported by the literature.

Motor Control Theories

- Reflex theory
- Hierarchical theory
- Systems theory

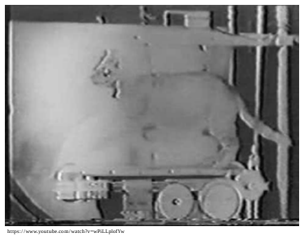
Relating Theory to Neurorehabilitation



(adapted from Shumway-Cook & Woollacott 2012)

Motor Control

- Reflex theory
  - Complex behavior can be explained through the combined action of individual reflexes that have been chained together
- Hierarchical theory
  - Top-down organizational control, i.e. higher brain centers control lower brain centers
  - Lines of control do not cross and there is no bottom-up control



https://www.youtube.com/watch?v=wPiLLpIuFYw

Classic Neurorehab Approaches

- Rood Approach
  - Margaret Rood, PT, OT
- Brunnstrom Stages of Recovery & Technique
  - Signe Brunnstrom, PT
- Neurodevelopmental Technique (NDT)
  - Berta Bobath, PT, and her husband Karel Bobath, MD
- Proprioceptive Neuromuscular Facilitation (PNF)
  - Herman Kabat, MD, PhD, Margaret Knott, PT, and Dorothy Voss, PT

Rood Approach

- Developed based on the reflex motor control theory and contribution of sensory receptors to movement
- Sensory stimulation to facilitate or inhibit postural tone and movement patterns
- Sensory stimuli directed towards activation of muscle spindles or cutaneous receptors
  - Facilitation vs. inhibition

Rood Approach:

Neurofacilitation Through Sensory Stimulus

- Facilitation
  - Light touch
  - Fast brushing
  - Ice application (quick icing)
  - Quick stretch
  - Tendon tapping
  - Vibration
  - Heavy joint compression
  - Traction
  - Resistance
- Inhibition
  - Slow stroking
  - Warming
  - Prolonged cooling
  - Prolonged stretch
  - Tendon pressure

Which technique under Rood's theory is inhibitive?

a. Quick stretch
b. Light tapping
c. Deep pressure
d. Brushing

Brunnstrom Stages & Technique

Stage 1	**Immediately following a stroke there is a period of flaccidity whereby no movement of the limbs on the affected side occurs**
2	Recovery begins with developing spasticity, increased reflexes and synergies may manifest with the inclusion of all or only part of the synergic movement pattern and they occur as a result of reactions to stimuli or minimal movement responses
3	Spasticity continues to decline, and there is a greater ability for the patient to move freely from the synergy pattern. Here the patient is also able to demonstrate isolated joint movements and more complex movement

- Techniques related to stages 1-3
  - Facilitating synergy patterns (not used today)
  - Overflow
  - Sensory stimulation to elicit movement

Brunnstrom Stages & Technique

Stage 4	**Spasticity and the influence of synergy begins to decline and the patient is able to move with less restrictions. The ease of these movements progresses from difficult to easy within this stage**
5	Spasticity continues to decline, and there is a greater ability for the patient to move freely from the synergy pattern. Here the patient is also able to demonstrate isolated joint movements and more complex movement
6	Spasticity is no longer apparent, allowing near-normal movement and coordination
7	Normal movement restored

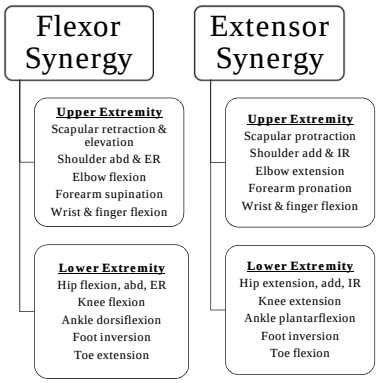
- Techniques related to stages 4-6
  - Movements out of synergy encouraged as patient gains additional control

What Brunnstrom stage is this patient in?

- Patient is starting to get some movement but is only able to flex arm at elbow, and at wrist in response to you touching their arm. They are not able to straighten their elbow to put arm at side. They are hyperreflexic.

a) Stage 1
b) Stage 2
c) Stage 3
d) Stage 4
e) Stage 5

Extremity Synergies



Extremity Synergies

https://www.youtube.com/watch?v=jOHhGS-XQPg

Which one of these synergy patterns is not correct?

a. Hip adduction, hip extension, hip internal rotation
b. Hip abduction, hip flexion, hip external rotation
c. Hip adduction, hip internal rotation, knee extension
d. Hip adduction, hip flexion, hip internal rotation, ankle plantarflexion
e. Hip abduction, hip flexion, knee flexion, ankle dorsiflexion

Shoulder Protection

- Shoulder subluxation
  - 17-81% of patients following stroke experience shoulder subluxation
  - Biomechanical factors contribute to glenohumeral joint stability are interrupted
  - One source of shoulder pain post-stroke
- Shoulder pain
  - 75% of patients with hemiplegia experience shoulder pain during the 12 months after stroke
  - Most commonly occurs 8–10 weeks post-stroke

(Turner-Stokes & Jackson 2002; Paci 2005; Umphred 2007; Price & Pandyan 2001; Koog 2010; Li & Alexander 2015)

Shoulder Protection

- Positioning
- Appropriate passive range of motion
- Slings
- Taping
- Neuromuscular Electrical Stimulation
  - Effective for *PREVENTION* of subluxation if applied early (<6 months post stroke)

(Griffin 2014; Vafadar 2014)

Which one of these items is not important when considering shoulder protection of the hemiplegic shoulder?

a. Consider proper support and positioning in bed with pillows.
b. Make sure adequate range in maintained as strength is returning.
c. Use shoulder as frequently as possible, no pain, no gain with motor recovery.
d. Use supportive sling when upright to avoid shoulder subluxation.

Neurodevelopmental Treatment (NDT)

- Analyzing components of functional movement and the development of functional movement patterns
- Emphasizing postural control
- Normal and abnormal movement affect the whole body
- Key points of control
  - Suppress abnormal patterns and facilitate more normal patterns
- Facilitation and inhibition to produce more efficient posture and improved function

Proprioceptive Neuromuscular Facilitation (PNF)

- An integrated approach aimed at eliciting the untapped existing potential for movement to help patients achieve their highest level of function
- Often functional diagonal patterns of movement are utilized:
  - Upper extremity
    - Tennis serve- arm and trunk diagonal activity
  - Lower extremity
    - Lower body dressing- trunk diagonal movement with leg flexion and extension diagonal movement

Proprioceptive Neuromuscular Facilitation (PNF)

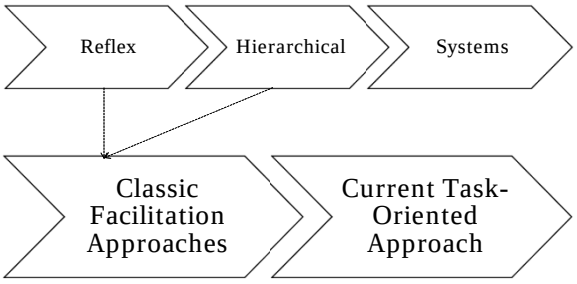
- Basic principles and procedures for facilitation:
  - Resistance
  - Irradiation and reinforcement
  - Manual contact
  - Stretch
  - Timing
  - Patterns
  - Visual stimulation
  - Traction or approximation
  - Auditory stimulation (commands)

(Adler, Beckers & Buck 2014)

What sentence best describes Proprioceptive Neuromuscular Facilitation (PNF)

a. PNF is focused on normal movement and extinguishing abnormal patterns.
b. PNF is focused on assigning people to stages of stroke recovery.
c. PNF is focused on use of functional diagonal patterns for facilitation of movement.
d. PNF is focused on facilitation techniques, including brushing, stroking, tapping.
e. a. and c.

Relating Theory to Neurorehabilitation

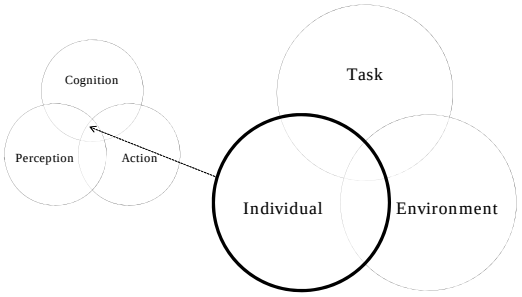


(adapted from Shumway-Cook & Woollacott 2012)

Motor Control

- Systems Theory
  - Understanding the neural control of movement within the context of the system in which you are moving
    - External and internal forces acting on the body
    - The same central command could result in different movements because of the interplay between external forces and variations in the initial conditions
  - "Movement is not determined solely by the output of the nervous system, but is the output of the nervous system as filtered through a mechanical system, the body." -Shumway-Cook & Woollacott 2012

Expanded Understanding of Motor Control



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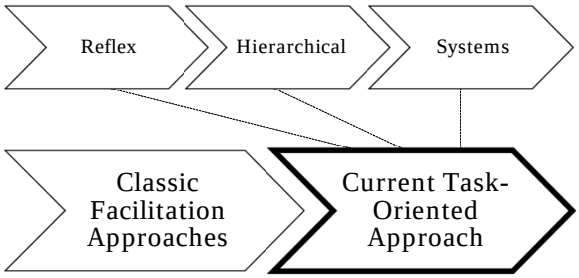
Neurorehabilitation Best Practice



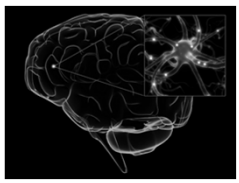
(adapted from Shumway-Cook & Woollacott 2012)

Neuroplasticity

- Definition
  - Ability of neurons to change function, chemical profile or structure
  - Can be adaptive or maladaptive
- Adaptive functional changes allow:
  - Memorization of new fact or mastery of new skill
  - Adjustment to new environment
  - Recovery from injury

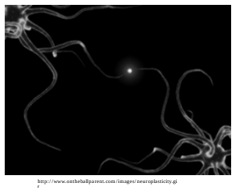
Neuroplasticity

- Driven by:
  - The genetic code (nature)
  - Experience (nurture)
  - Injury (need to adapt)
- Involved in:
  - Normal development
  - Learning/memory
  - Recovery from injury

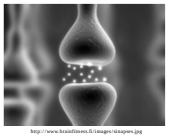


http://superbodysuperbrainblog.files.wordpress.com/2011/10/bigstock_human_brain_1012552.jpg?w=640&h=450

Cellular mechanisms of Plasticity



http://www.onthehalfpoint.com/images/neuroplasticity.gif



http://www.brainfitness.fi/images/sinapses.jpg

- Morphological
  - Synaptogenesis
  - Neurogenesis
  - Angiogenesis
- Physiological
  - Synaptic efficacy
  - Membrane excitability
  - Blood flow

Neuroplasticity Principles

1. **Use it or lose it**
2. Use and Improve it
3. **Specificity**
4. **Repetition Matters**
5. **Intensity Matters**
6. **Salience Matters**
7. Time Matters
8. Age Matters
9. Transference
10. Interference

http://depressiontreatments.net/wp-content/uploads/2012/01/Brain-Power.jpg

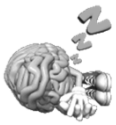
http://depressiontreatments.net/wp-content/uploads/2011/09/Neuro-Plasticity-For-Healing-Mental-Health.jpg

(Kleim & Jones 2008)

Other factors that affect Plasticity

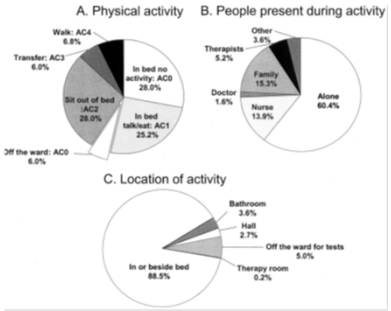
- Experience (activity)
- **Sleep**
- Mood
- Hormones
- Cardio-respiratory function
- Diet
- Pharmaceuticals

http://www.bestsummerce.org/wp-content/uploads/2011/11/different-stages-of-sleep1.jpg



http://www.ebrainsupplements.com/wp-content/uploads/2011/07/nootropics-sleep.gif

Amount of activity provided 14 days post-stroke is minimal

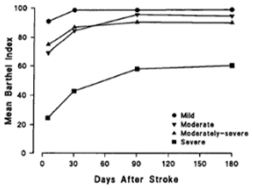


According to the research….

- Animal studies show:
  - 2,500 hand movement repetitions over 5 days
  - >2,000 steps **<u>each training session</u>** may be needed
- Comparison of practice occurring in our clinics:
  - Functional UE movement in 50% of sessions addressing upper limb rehab; avg. # of reps = 32.
  - Gait practice in 84% of sessions addressing lower limb rehab; avg.# of steps = 357.

(Boyd 2003; 2004; 2008; 2009; 2010; Kimberly 2010)

Timing Matters



- Greatest improvements in first 30 days post-stroke
- 6 months post-stroke considered transition to chronic stage where improvements not as rapid
  - Functional changes **<u>are</u>** possible in the chronic stage

(Jorgensen 1999; Wade & Hewer, 1987; Duncan 1992; Duncan 2000; Wade 1985; Bonita 1988; Luft 2004; Macko 2001)

Aerobic activity and its impact on neuroplasticity

- Upregulation of brain-derived neurotrophic factor (BDNF)
- Enhance long term potentiation
- Promote neurogenesis –Promote angiogenesis – Suppress oxidative stress
- Increase insulin-like growth factor
- Increase neurotransmitters

(Mang, 2013)

Forced Use To Assist with Neurological Return

- Constraint induced
- Hemi-techniques discouraged- Compenstory versus Recovery
- Parkinson's research with tandem bike- Here at UWMC

Constraint-Induced Movement Therapy (CIMT)

- Constraint-induced therapy (CI) involves constraining the unaffected limb, and spending several hours a day solely using the affected limb. It teaches the brain to "rewire" itself following and injury to the brain. Research has shown to significantly improve the quality of the movement, and the amount of movement in the affected extremity for common activities of daily living

(Lang, Thompson, Wolf 2007)

Constraint-induced Therapy is best described as:

a. Reducing unwanted tone in affected limb by restraining it to allow relaxation.
b. Restraining affected limb several hours a day so negative patterns are not developed as strength emerges.
c. Restraining unaffected arm for several hours a day to promote reshaping and improving use of affected arm by increased use.
d. Restraining unaffected arm to limit overall activity so that negative tone does not increase.

Mirror Therapy

- Effective for improving motor function following stroke
- Evidence suggests it could improve
  - Upper extremity function
  - Lower extremity function
  - Gait
  - Unilateral neglect
  - Possibly Broca's aphasia

(Thieme 2012; Samuelkamaleshkumar 2014; Ji & Kim 2014; Pandian 2014; Pandian & Arya 2014)

http://stroke-rights.ca/intervention/index.php?page=opioidsheep-age=patient-kid=49

http://physicaltherapy.advanceweb.com/Features/Articles/Mirror-Therapy.aspx

Devices Used for Gait Training: Lite Gait

- Unweights patient in harness
- Allows for them to get safely on their feet sooner
- Allows for greater intensity of stepping, higher aerobic and neuromuscular demand

Starting out gait training with lite gait

Lokomat

- Easier to get more steps due to not high demand of manpower
- Robotic arms assist in moving legs forward
- Does not allow for error and correction

Lokomat

Effects of Forced Exercise in Animal Models of Parkinson's Disease

• Increased release of dopamine

• Decreased synaptic clearance of dopamine

• Increase in neurotrophic factors (BDNF,GDNF, IGF-1)

– Greater intensity (forced-exercise) results in higher levels of neurotrophic factors and more extensive the anatomical regions involved

Tandem Biking with Parkinson's Population

Improvements seen in handwriting, sense of smell, aerobic condition, mood, and motor recovery.

ReWalk

- ReWalk is a wearable robotic exoskeleton that provides powered hip and knee motion to enable individuals with Spinal Cord Injury to stand up and walk.
- Program is up and running at the University of Washington

ReWalk

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