The Physiology of Learning

Mary Schira PhD, RN, ACNP-BC
schira@uta.edu

Focus of Session

- How does learning happen?
- What is the role of attention, memory, information processing, recall?
- How do disease states affect – alter the ability to learn?

Learning

- Process that modifies behavior
- Requires attention, short term/working memory, long term memory, retrieval of memory information
- Need to manage working memory capacity
- Facilitate information transition from short (working memory) to long term memory

Central Nervous System

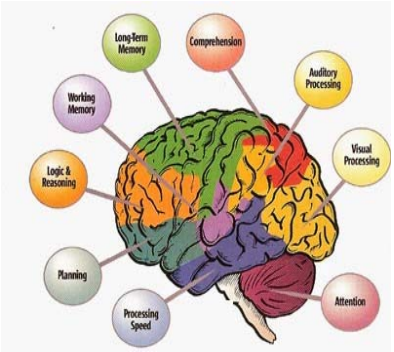
- All information passes through CNS (incoming stimuli + outgoing responses).
- Information is mediated within CNS
- Information carried by neurons, passed from neuron to neuron
- Within neuron, information transmitted electrically due to flow of ions
  - Relies on action potentials, synapses, neurotransmitters
- Significant change in brain during cognitive task – increased blood flow, especially frontal cortex

Synapses and Learning

- Neuron fires – creates action potential – synapse – chemicals released from vesicles – enter synaptic cleft – chemicals taken up – repeat
- Every time learn, neural circuits in brain change
- Efficiency of synapses increase – as result, passing impulses facilitated

Memory

- Essential to all learning
- Allows to store and retrieve information
- PROCESS
- No single place, structure in brain where occurs or stored



Attention is basic….

- Increases sensitivity of brain to information
- Focuses neural energy
- Reticular Activating System relays messages to the brain
- Voluntary and involuntary

Short Term Memory

- Frontal lobe
- Keeps information "online" so can manipulate, use the information
- Need for concentration, follow instructions
- In order to work, need to remain focused and block distractions (attention).

Short Term Memory

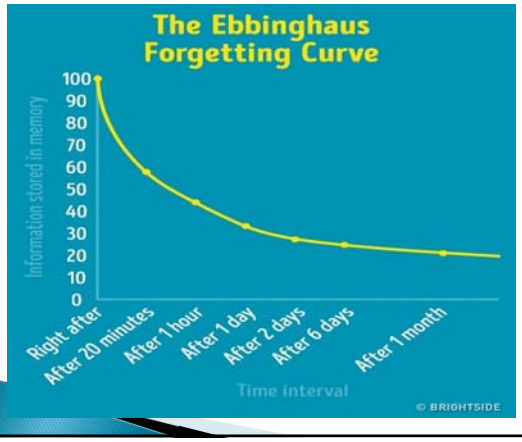
- Stores sounds, images, words
- 3 Operations
  - Iconic (image)
  - Acoustic (sound)
  - Working (store until use)
- Sorted, coded/compared, rehearsed, remodeled

Working Memory

- Operates within short term memory
- Manipulates information temporarily
- 4-5 pieces of information; 10-15 seconds
- Discard the info OR help move the info to long term memory
- Helps process, store, retrieve from long term memory
- MEANING MATTERS

Working Memory

- Why discard?
  - Not enough time to move to long term
  - Lack of interest
  - Competition of new information
  - Decays
- Takes neural effort to keep data in working memory
- When exceed 15"ish" seconds, can overload
- Overload decreases function AND ability to retain



Long Term Memory

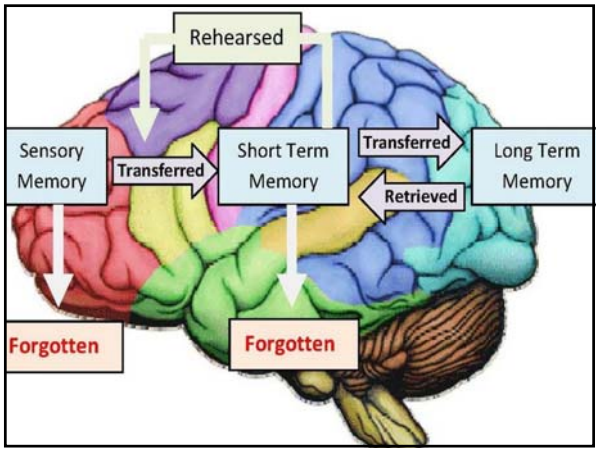
- Temporal lobe
- Store information based on meaning and importance
- Store for extended period of time
- Memories are finite (don't use it, you lose it)
- Provides framework for new information – create knowledge structures by association
- Each time a memory is retrieved for comparison and remodeled, becomes more permanent

Long Term Memory

- 2 Types
  - Explicit
  - Implicit
- 3 Operations
  - Encode
  - Store
  - Retrieve

Long Term Memory

- Not capacity limited
- Activate long term memory
- Links and add new to existing old
- Associate then accommodate



Effects of Physiologic Environment

- Electrolyte balance, availability
- Disease processes
  - Heart Failure
  - Diabetes
  - Cancer therapy
- General anesthesia
- Sleep

Sleep

- Supports brain plasticity and learning
- REM sleep and slow wave sleep
- Lack of sleep decreases ability to consolidate/associate memories
- Multiple reasons for poor sleep in CKD (restless legs, sleep apnea, sleep hygiene)
- Poor sleep decreases Insulin sensitivity
- Neurohormonal state of brain best early morning

Physiologic Environment – CKD

- Hyperparathyroidism
- Anemia
- Cardiovascular disease
- Prior stroke
- Reduced gray matter volume
- Oxidative stress
- Chronic volume overload

Patterns of Impairment – ESKD

- Consistent deficits across range cognitive domains along continuum of severity
- Attention, executive function, working memory
- Clinical and subclinical
- In Hemodialysis (majority of work)
  - Executive function decreases over time
  - Memory may stabilize and/or improve with dialysis
  - Improvement is "relative"
- Less information related to peritoneal dialysis and transplant

"Executive Function"

- Ability decide, plan, implement and evaluate behavior for specific goal
- Involves memory, processing information
- Prefrontal, frontal, cortex

Examples from the Literature

O'Lone, E. et al (2016). Cognition in People With End-Stage Kidney Disease Treated with Hemodialysis: A Systemic Review and Meta-Analysis. American Journal of Kidney Disease, 67, 925-935.

- 42 studies; 3500 participants
- Deficits in attention, memory, executive function > general population.
- No major differences between HD and PD or non-dialysis CKD
- Suspected etiologies
  - Accelerated aging
  - Vascular type dementia

Weiner, D., et al. (2017). Cognitive Function and Kidney Disease. American Journal of Kidney Disease, 70, 357-367.

- SPRINT-MIND (cognition substudy SPRINT)
- 2700 participants
- Higher Albumin:creatinine ratio associated with poorer executive function, attention
- Lower eGFR associated with poorer executive function, attention, memory

Drew, D. (2017). Cognitive Decline and Its Risk Factors in Prevalent Hemodialysis Patients. American Journal of Kdney Disease, 69, 780-787.

- 314 participants, evaluated yearly for avg. 2 yrs.
- Measured during 1st hr of HD treatment
- Significant decline executive function
- Significant increase memory
- Proposed explanation
  - Age "matters" more for executive function than memory
  - Baseline CVD, DM non-significant decline for executive function, not memory
  - Dialysis vintage not significant for either

Henry, S., et al. (2017). The Effect of the Interdialytic Interval on Cognitive Function in Patients on Haemodialysis. Journal of Renal Care, 44, 44–51.

- 26 participants
- Measured during short & long interdialytic intervals
- Cognitive function tests + ecological momentary assessment
- Working memory, recall, memory diminished but not "substantial"
- No consistent relationship cognitive function tests and reports of impairment

How do we maximize learning?

- ONE way is to manage limitations of working memory
- HOW?
  - Move from easy to challenging material
  - Limit distractions
  - Provide practice
  - "Chunking"
  - Small parts at a time
- Activate long term memory
  - Link new to existing old
  - Associate and accommodate☺.

Take Homes

- Need "intact" cognitive functions for learning.
- Executive function, memory impaired when compared with general population
- Treatment may improve some functions but not to "normal"
- Incorporate understanding of how memory "working" into patient education interventions.