WHY DO MY STUDENTS DO THAT?

PRACTICAL APPLICATIONS OF NEUROSCIENCE IN THE CLASSROOM
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Objectives

- Understand the stages of neuronal development and how damage at different stages can impact disability
- Discuss the function of the motor systems and their impact on school function
- Understand motivational pathways and their effects on attention and behavior
NEUROGENESIS

- Cell Division occurs at conception:
  - Stem cells: cell division
  - Stem cells: neuroblasts and glioblasts

- Neural tube is formed
CELL BIRTH (neurogenesis)

Forebrain

Midbrain

Hindbrain

Telencephalon (Cerebral Cortex)

Diencephalon (thalamus)

Pons

Cerebellum

Medulla Oblongata
CELL MIGRATION AND DIFFERENTIATION

I  II  III  IV  V  VI

Neuroglia  Germinal Zone  Ventricle & CSF  Mother Cells  Daughter Cells
Cell Migration and Differentiation

- Neuroblasts travel out from the ventricular zone (inside of cylinder) to predetermined destinations along radial glial cells (vines).

- Six layers of the brain are formed and the cells lay down backward from layer six (inner most part of brain) to layer one (outer most part).
LAYERS OF THE BRAIN

- **V AND VI**
  - Large cells send info long distance
  - Motor cortex
  - Output to other parts of the brain

- **IV**
  - Input of sensory information

- **I, II, III**
  - Integrative functions
Once cells reach their predetermined destinations, dendrites begin to proliferate (imagine a tree in winter)

- Six dendritic branches by birth
- Grey matter: synaptic potential; neuroplasticity
SYNAPSE FORMATION AND PRUNING

- Synapsing has to occur between many of the dendrites
- **SYNAPTOGENESIS**
- Pruning is just as important
  - Initially, there are far too many cells and they have to be pruned to allow for accurate synapsing and specialization.
  - Pruning continues throughout life
Limited pruning denies fine tuning
MYELOGENESIS

- Begins around 5 months in utero
- Big boost in the first year
- Another small boost between 2nd-4th years
- Can continue through out life
- White matter: processing speed
If neuronal machinery is not there, a behavior cannot exist.

Only if the machinery exists can experience with the environment allow for function to develop.

THERAPY ENRICHES A CHILD’S POTENTIAL.
NEUROANATOMY OF THE MOTOR SYSTEM

(...A sampling of the motor system)
Why does motor matter?

- **Co-contraction of core**: Staying seated
- **Body awareness and motor control**: Walking down the hallway “on the second square”
- **Body awareness**: Moving through crowds
- **Motor planning/sequencing**: Following classroom routine
Why does motor matter?

- **Fine motor control**: Writing
- **Impact on social skills**: engaging in PE and recess
- **Fatigue**: maximizing energy required for attention and learning
COMPONENTS OF THE MOTOR SYSTEM

- Corpus Callosum
- Basal Ganglia
- Cerebellum
- Frontal Lobe: Motor Cortex
- Parietal Lobe: WHERE am I?
CORPUS CALLOSUM

- White matter
- 200 to 800 million fibers
- Projections from one hemisphere connect identical contra lateral points
- Projections zones within a hemisphere also connect to identical contra lateral points as well as diffuse distribution pts
CORPUS CALLOSUM

http://www.mult-sclerosis.org/corpuscallosum.gif

Liepmann’s Theory of Apraxia

Normal Response
- Verbal command to move left hand processed in left hemisphere
- Corpus Callosum connects information to right motor hemisphere to move left hand
- Left hand moves
Liepmann’s Theory of Apraxia

Apraxic Response

- Verbal command correctly processed
- Information not given to right hemisphere
- No movement takes place
THE CEREBELLUM
CEREBELLUM

- Coordinates and “smooth’s out”:
  - Eye movements
  - Thought patterns
  - Cadence of speech
THE CEREBELLUM

- Cerebellum
  - 10% brain volume
  - 50% neurons
  - Folded like an accordion – 1 m
  - Vestibulocerebellum
  - Spinal Cerebellum
  - Cerebrocerebellum/Neocerebellum

http://www.colorado.edu/intphys/Class/IPHY3730/05cns.html
VESTIBULOCEREBELLUM

- oldest part of the cerebellum
- involved in vestibular reflexes and postural maintenance
- No to minimal connections from cerebral cortex via pontine nucleus to this lobe
SPINOCEBELLUM

- Adjustment of limb movements
- Involved in error correction: integrating sensory input with motor input for adaptive motor responses: ex, tripping.
CEREBROCEREBELLUM

- Coordination of fine skills including motor, thoughts, emotions, eye movements
- Planning and timing of movements
- Involved in the cognitive functions of the cerebellum
CEREBELLUM AND PREFRONTAL CORTEX

- Cognitive task is difficult
- Cognitive task is new as opposed to practiced
- Conditions of cognitive task change vs. stable and predictable
- Quick response required
- Concentration required vs. automatic pilot
- Involved in planning & working memory
Feedforward Loops

- Internal self-correcting loop
- Imagine throwing a dart: there are two movements
  - The movement you intended
  - The movement you actually did
- The body receives sensory input from the environment and self; compares, contrasts; learns through trial and error and attempts to improve performance
- Mossy fibers receive input from spinal cord, cerebral cortex, reticular formation
- Provide instructions for sequencing, timing, rhythm of desired goal (motor, thought, speech, cognitive)
- Purkinje cells receive input via climbing fibers from inferior olivary nucleus
- Provide comparator to change subsequent action for improved performance
CEREBELLAR DYSFUNCTION

- Deficits in motor learning
- Decomposition of movement
- Hypotonia
- Muscle Weakness
- Fatigue: too much energy is required for stabilization
- Ataxia
SO these children struggle to learn because too much energy is required to focus on movement and posture.

The glucose and oxygen needed for learning is being expended elsewhere.
BASAL GANGLIA

- Motor Program, Speed and Skill of movement
  - Example: motor program for showering
- Grouping of Nuclei: caudate nucleus, putamen, globus pallidus, substantia nigra, subthalamic nucleus
BASAL GANGLIA
SAGITTAL VIEW

http://www.profelis.org/amc/ap1/gifs/basal-ganglia_normal.gif
THE BASAL GANGLIA

- It takes 18-20 years to achieve the highest level of skill in this system
- Sportsmen in their prime years
- Functions together with the cerebellum as we have to smooth out and coordinate this speed and skill
INTRINSIC PATHWAYS

DIRECT PATHWAY

- Involves CC exciting striatum:
- Excites thalamus which excites motor cortex
- Facilitates motor or cognitive programs required for desired task

INDIRECT PATHWAY

- Involves CC exciting striatum:
- Inhibits thalamus so unable to excite motor cortex
- Inhibits competing motor programs to allow execution of desired task
Nico
CEREBRAL CORTEX
FRONTAL LOBE

- Primary Motor Cortex: execution of voluntary movement
- Premotor and Supplementary motor cortices
- Frontal Eye Fields
PARIETAL LOBE

- WHERE?
- Guidance of Movement
- Position in space
- Parietal Eye Fields
- Reach/Grasp
A. Reaches (Area PRR) and Reaches (PMd)
Saccades (Area LIP) and Grasping (Area AIP)
Saccades (FEF)
Grasping (PMv)

B. Parietal-frontal circuitry
Sensory input: LIP → Saccade → FEF → Motor output
Motor output: PMd → Reach → PRR → Sensory input
Why does motor matter?

- How could it not?
- What do we do about it?
  - Educate! No, it is just not that easy to walk on the second square
  - Jammin’ minute
• S’cool moves:  
  https://www.schoolmoves.com/

• Brain Gym:  
STRATEGIES

- **Seating Position:**
  - Turn the chair around to support the trunk
  - Tennis balls on alternating front and back legs of the chair
  - Allowing alternate seating positions such as child sitting on their feet, standing, or sitting on the edge of the seat
  - Ball chairs, t-stools, sit ‘n moves, backjack chair, howdahug chair, body sock
STRATEGIES

- Transitions
  - Allow the child to carry items: increases proprioceptive awareness
- Use sensory strategies to help increase level of arousal/muscle activation
  - Mints, cinnamon, gum
  - Arrhythmic music
  - Irregular vestibular input
STRATEGIES

- Incorporate strength, endurance, motor planning
- Working in prone
- Worksheets in the vertical plane on the wall
- Writing in “sit-up” position
- Brain Gym’s during transitions
- Motor tasks paired with math facts, rote counting, spelling words.
- Suggestions from the group?
INATTENTION AND STRESS ... OR BEHAVIOR!

(....sound familiar?)
THE LIMBIC SYSTEM

Amygdala and Hippocampus
Everything we want to remember is sent from cortex to hippocampus.

All memory is not stored in hippocampus.

Further back in past – the more embedded memories become in surrounding cerebral cortex.

Large pyramidal cells that are functioning 24 hours a day and in constant need of oxygen and glucose….what if this is being expended elsewhere?
AMYGDALA

- Integrative center for emotions, emotional behavior and motivation
- Inputs from all sensory cortices via olfactory bulb, temporal and anterior cingulate cortices
- Efferents to brainstem, thalamus, basal ganglia, hippocampus, frontal cortex
- Visceral input from hypothalamus, septal area, orbital cortex, and parabrachial nucleus
  - Gut Reaction
What happens when the sensory stimuli is too overpowering?

- A stronger sense of emotion is created
- Stronger messages are sent to the autonomic nervous system
- Respond with the “not-so-desired” response –
  - Fight/flight/fright
  - Article: adult with melt down.
MADALYN
AMYGDALA

- Fear
- Frustration
- Anger
- Rage
- Violence
AMGYDALA

- Results in:
  - Poor Coping
  - Over reactive
  - Irrational
  - Lack of Inhibition
  - Acting out without the ability to control it, and limited awareness as to why
NEUROTRANSMITTERS AND ATTENTION
DOPAMINE AND ATTENTION

- Conscious and intentional control of coordination and movement
- Mediate emotions
- Compulsion and Perseveration
- Sensitive toward rewards
  - respond to novel stimuli, unexpected rewards, and reward predictive sensory cues
DOPAMINERGIC PATHWAYS

- Mesolimbic pathway
- Mesocortical pathway

MESOLIMBIC PATHWAYS

- Reward pathway/Stimulus Reward Learning
  - Dopamine released when reward anticipated
  - Relates to hyper-attentiveness to topic of interest
  - Inability to attend when of no interest
MESOCORTICAL PATHWAYS

- Project to Prefrontal Cortex
- Allows for active suppression of distractions
- Inhibition of inappropriate expression of tangential thoughts, ideas, or behaviors

Understand consequences?
- should these children just be expected to “know better”?
NOREPINEPHRINE

- Hormone and neurotransmitter
- Underlies flight/fright system
NOREPINEPHRINE

- Novel or intense stimuli trigger its release

- **Role:**
  - Alertness
  - Attention and Focus
  - Arousal
  - Influences on the Reward System
  - Memory storage and retrieval
FUNCTIONAL IMPLICATIONS

- Flight/fright:
  - Epinephrine: pulse rate, sweating
  - NE: Cognitive mental alertness to facilitate executive functioning and reasoning
  - Ex: Walking alone in parking lot
  - Child in state of heightened arousal?
    - Behavior hyperactivity
    - Emotional reactivity
STRATEGIES

- Reward systems
- Decrease stress: create safe, secure environment
- Visual schedule and visual sensory diet
  - aid in anticipation; decrease stress
- Motor activity
- Novelty
Remind colleagues, parents, and teachers that a child is still just a child. We barely understand the reason for their behavior and weaknesses, so how could they?