Brain and Central Nervous System

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Agenda

- Development of the Central Nervous System
- Genetics vs The Environment
- Six stages of Brain Development
- The Parts of the Brain
- The Parts of the Central Nervous System
  - The Peripheral Nervous System
    - The somatic and autonomic nervous system
- Brain Imaging

Brain and CNS Development

- The nervous system is the body's computer
- It coordinates and directs various body systems via billions of cells which connect the brain to carryout conscious and unconscious functions
  - Major components are
    - Central nervous system CNS
      - Brain and spinal cord
    - Peripheral nervous system
      - Somatic nervous system: sensory and motor nerves
      - Autonomic nervous system: automatic functions

Development of the Central Nervous System

- CNS begins to form during the third week of gestation
  - Part of the outer layer forms into a shoe shaped body called the Neural Plate
  - This plate expands and rises to become the Neural Groove
  - When this closes it forms the Neural Tube
  - At this time the CNS looks like a closed tubular structure with a tail and a head.
  - The tail will become the spine
  - The broader head portion will form the brain
  - The hollow tube persists and becomes the ventricular system of the mature brain.

Development of the CNS

- The head portion with three portions becomes the three distinct subdivision of the brain
- Forebrain-prosencephalon
  - This forms the cerebral hemisphere
- The basal ganglia and the thalmus-mesencephalon
  - This forms the Midbrain - mesencephalon
- Hindbrain-rhombencephalon
  - This forms the cerebellum and the brainstem
- These parts of the brain bend into their shape at 5 weeks from conception
- When fetus is 3 months old, all brain structures are in place!

Genetics versus Environment

- Scientists have long debated whether the processes involved in brain development are genetic or environmental.
- With your table group discuss the following:
  - What genetic factors do you believe affect brain development?
  - What environmental factors do you believe affect brain development?
  - What other factors might affect brain development?

Six Stages of Brain Development

- Neuration
  - 3-7 weeks gestation- Neural tube formation
  - If neural tube is incomplete-meningomyelocele (spina bifida or anencephaly
  - Requires correct anterior-posterior positioning of cells along the tube
- Prosencephalic Development
  - Second and third trimester- five cerebral vesicles develop from the forebrain
  - Formation of the face, cleavage of the hemispheres and ventricles
  - Disorders- nonviable cyclops, close eyed with single incisor and cleft lip and palate, incomplete cerebral lobes and absence of corpus collosum

Six Stages of Brain Development

- Neuronal Proliferation
  - Third and fourth month of gestation-nerve cells rapidly divide prior to migration into upper layers of brain
    - Neuron has cell body consisting of nucleus and cytoplasm
      - Unlike other cells has a long process called an axon which extends from the cell body with many shorter jutting processes called dendrites
    - If disorders affect proliferation of neurons at this stage, child will have microcephaly or small brain.
      - Usually associated with mental retardation
- Neuronal Migration
  - Occurs between 3 and 5 month's gestation- neurons radially migrate into the cortex and cerebellum
    - Brain expands as does complexity of nerve layers
    - Migrate from the bottom layer toward the top
      - Adult brain has 6 layers
    - Incomplete migration can cause mental retardation and seizures

Six Stages of Brain Development

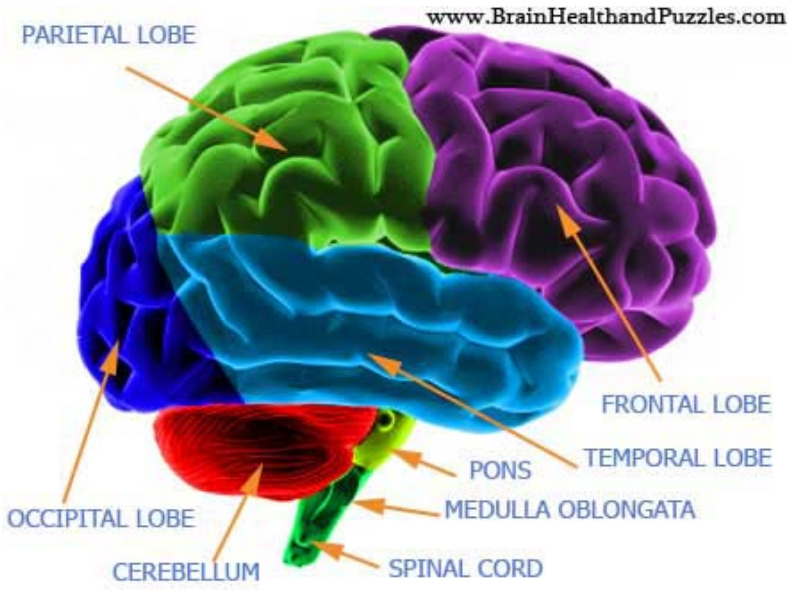
- Neuronal Differentiation and Organization
  - Begins at 5 month's gestation and continues through early childhood
    - This period of brain development involved the outgrowth of axons and dendrites, the formation of synapses and the selective elimination of neuronal processes
      - Axon and dendrites have different function
      - Axons carry impulses away , and can cover a distance of 1 meter
      - Dendrites receive , and carry them short distances toward the cell body
      - Impulses are transmitted from one neuron to another across a synapse.
      - The terminal of axon of one neuron almost touches either the dendrites or the cell body of another neuron. When the impulse reaches the presynaptic membrane , it cannot cross the synaptic cleft without a bridge with out the release of a neurotransmitter.

Six Stages of Brain Development

- Myelination
  - Neurons of brain and spinal cord from two distinct regions of the CNS called the gray matter and white matter
    - Gray matter- nerve cells and bodies
    - White matter- axons sheathed with a protective covering called myelin aiding in more rapid conduction of impulses
    - During fetal life, no myelin coating, but starts to develop shortly after birth.
    - Necessary for development of gross and fine motor movement and suppression of primitive reflexes
    - Usually completed by 18 months of age

The Mature CNS: Brain and Spinal Cord

- Weighs 3 pounds, has four parts: cerebral hemispheres, the basal ganglia and thalmus, the brainstem and the cerebellum
- Cerebral Hemisphere
  - Anatomically divided into 4 lobes
    - Frontal lobe occupies the front third of hemisphere
    - Occipital lobe takes up the back fourth
    - Parietal lobe sits in the middle-upper part
    - Temporal lobe in in the lower middle region
  - Surface of the cerebral hemisphere is called the cortex, made up of gray matter which has white matter beneath
  - Initiates motion and thought and adds flexibility to the more reflexive involuntary brainstem



Group Work
Numbered Heads

- Describe the brain functions for the area of the brain assigned to your group

1. Frontal Lobe
2. Occipital Lobe
3. Parietal Lobe
4. Temporal Lobe

The Brain

- The Basal Ganglia and Thalamus
  - Rests beneath the cortex, in the center of the brain in the area called the dicephalon. Adjacent are the basal ganglia.
    - Modifies and alters instructions from the motor cortex that control voluntary movement
    - Damage to this area lead to movement disorders
- The Brainstem
  - **Connects the cerebral hemispheres to the spinal cord. It has three regions**
    - **The medulla**
    - **The pons**
    - **The midbrain**
    - These parts send out 12 cranial nerves that control such diverse functions as breathing, swallowing, seeing and hearing. They also control facial expression, eye and tongue movements, and salivation.
    - Contains sections of the corticospinal tracts well as other nerve tracts that flow from the cortex to the spinal cord and sensory tracts that go from the spinal cord to the brain.

The Brain

- The Cerebellum
  - Develops from a portion of the brainstem and rests just below the cerebral hemisphere and behind the pons.
  - Coordinates the action of the voluntary muscles and times their contractions so that movement is smooth
  - Works with cerebral hemisphere and the basal ganglia so that we move efficiently
- The Spinal Cord
  - Has three layers called the meninges surrounding both the brain and spinal cord
    - It is the primary conduit to transmit motor and sensory messages
      - Damage creates a short circuit, so that messages cannot get from the brain to the body
      - Damage may result in both the loss of sensation and movement in the affected limbs

The Nervous System

- The Peripheral Nervous System
  - In the peripheral system, nerve impulses pass from the motor cortex to the motor neurons in the spinal cord and connect with a peripheral nerve which carries the impulse to the muscle
  - Peripheral nerves have fibers that **run in both directions**
    - Motor, efferent fibers bring signals from brain to muscle to cause movement
    - The interaction of these two allow smooth movement
    - Control both voluntary and involuntary movement

Think-Pair-Share

- What are the major differences between the somatic system and the autonomic system in the peripheral nervous system?

The Nervous System

- The Somatic Components of the Peripheral System
  - Is part of the peripheral nervous system that controls voluntary movement
    - For proper muscle tone to occur, must have proper relationship between the motor and sensory fibers
    - It is not the muscle itself, but the activity of the nervous system which determines muscle tone
- The Autonomic Nervous System
  - Entirely different part of the peripheral nervous system
    - Takes care of involuntary activities
    - Controls functioning of cardiovascular, respiratory, endocrine, urinary, and reproductive systems
    - Has a “all-or-non-affect” rather than individual muscle movement
    - Changes that occur prepare a person to react to an emergency

The Cerebrospinal Fluid and Hydrocephalus

- Cerebrospinal fluid is clear, watery liquid that bathes the spinal cord and flows through the ventricles, or cavities in the brain.
  - Fluid serves as a buffer to protect the CNS from pressure changes and provided nutrition
  - Fluid flows from the ventricles in the brain to the space around the brain and down the meninges surrounding the spinal cord to the base of the spine.
  - If flow is obstructed hydrocephalus occurs: fluid backs up into the brain
    - Intracranial pressure can cause brain damage and coma
    - Hydrocephalus has many causes: spina bifida, meningitis, intraventricular hemorrhage
    - Usually treated with medication or a shunt where the fluid drains into the peritoneal cavity and is reabsorbed

Imaging the Brain

- High speed computer tomography- CT
  - Evaluation for hydrocephalus, seizure disorders, trauma, craniofacial disorders and tumors
- Magnetic Resonance Imaging (MRI)
  - Evaluation of developmental brain abnormalities and epilepsy and to detect metabolic abnormalities
- Single Photon Emission Computed Topography (SPECT) and Positron Emission Tomography (PET)
  - Demonstrate metabolically active regions in the brain
  - Radioactively labeled compound injected in bloodstream and SPECT or PET used to assess its selective uptake up in various brain regions
  - Used to diagnose strokes, tumors, and brain injury
- Functional MRI (*f*MRI)
  - Uses MRI to study the effects of attention and activity on brain function

Summary

- The CNS is composed of central and peripheral elements
- The CNS undergoes elaborate development and differentiation during embryonic development
  - Leaving it at risk for innumerable malformations
  - Some of these malformations result in developmental disabilities
- Understanding the development of the CNS helps us as educators to understand the disabilities that affect the children that we work with