Brain Resource Creation Workshop: Chapter 7 - Infant, Child, and Adolescent Brain

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The First Years of Life (Cont.)

- Brain grows due to the cells growing, proliferating (multiplying), differentiating (maturing), and migrating to different brain regions.
- During the first three months of life, the number of neurons in the cortex increases by 23–30%.
    - The dendrites and axons grow longer and make synapses (connections) through *synaptogenesis*
        - Makes brain larger
- Glial cells grow, multiply, and provide myelination by oligodendrocytes
- The brain's white matter = white → myelin-wrapped nerve fibers.
- At 5 years old, the brain has reached about 90% of its adult size.

The First Years of Life (Cont.)

- The **synaptic density** (connections between neurons) increases rapidly during the first couple years of life
  - A 2-year-old's brain has 50% more synapses than an adult brain, despite being only about 80% the size of an adult brain.
- Too many synapses = too much energy usage
  - Brain begins to reduce the number of synapses during early childhood.
- This synaptic pruning process is shaped by the growing toddlers' experiences.
- **Synaptic pruning** allows the destruction of weaker connections and the activation of stronger synapses that will grow & stabilize.

The First Years of Life

- Average brain-weight of a newborn = 370 grams
- Average weight of an adult brain = 3 lbs, with about 86 billion neurons.
- Takes 40 weeks to develop the newborn's brain
- Growth rate of brain
  - Immediately after birth = 1% per day
  - 0.4% per day by 3 months after birth;
    - Baby's brain volume is 64% larger now
    - The fastest-growing brain region (the cerebellum) is more than double its original volume
- *Cerebellum* = brain region with the most neurons; helps with learning motor skills and movements (ex. grabbing things and eating food).

Experience Shapes the Brain

- Humans are born with brains that take longer to mature
  - Ex. squirrel monkeys reach their adult brain size at 6 months
- Most of the human brain grows and develops after birth instead of in the womb
  - **Advantage** = easier for humans to adapt → developing brains are more easily shaped by environment and experience,
- Connections between neurons are shaped by a baby's early life experiences (during **critical periods** of development),
  - E.g. seeing parents' faces, hearing their voices, being held in its parents' arms
  - Provides important sensory, motor, and emotional inputs

Experience Shapes the Brain (Cont.)

- Genes and environment exert strong influences during **critical periods**,
  - Forms **neural circuits** → affect learning and behavior
- **Neuronal cell death** and **synaptic pruning** are both important processes in shaping connections
  - Occur in the embryo and in early postnatal life
- Changes in neural connections during critical periods = high rates of learning,
  - E.g. a toddler learning to run or speak multiple languages.

Into Adolescence

- Adolescence can be considered the **2nd critical period**
  - More complex functions of the brain develop and can be influenced by environment & experience.
- Synaptic pruning continues, along with a process called competitive elimination
  - **Competitive elimination** - stronger connections "beat out" weaker ones
- Brain improves its connections = neurons extend their dendritic branches and increase the myelination of axons, especially in the frontal lobes.
- Longitudinal studies are helpful for understanding how a brain changes between early childhood & adolescence.
  - (Note: these types of studies can reveal how early life events and environment can affect outcomes later in life, such as education or risk for disease)

Into Adolescence (Cont.)

- **MRI (magnetic resonance imaging)** images of the adolescent brain show an increase in white matter volume, especially in the corpus callosum (large bundle of myelinated fibers that connects the brain's right % left cerebral hemispheres).
- Corpus callosum growth may explain enhanced learning capacity in adolescence, due to the increasing connections.
- Enhanced connections, changes in the brain's reward systems, and changes in the balance between frontal and limbic brain regions can contribute to teenage behaviors such as increased risk taking and sensation seeking, which are aspects of an enhanced learning ability; unfortunately, this risk taking and sensation seeking also increase the risk of addiction.
- Some regard addiction as a type of acquired learning disorder, pointing to the overlap between brain regions involved in addiction and those supporting learning, memory, and reasoning.

Into Adolescence (Cont.)

- Frequent drug use during adolescence is associated with damage to brain regions vital for cognitive functions such as memory, attention & executive functioning.
- Studies using MRI to measure brain volume and a technique called diffusion tensor imaging (DTI) to study quality of white matter show that adolescents who used alcohol had reduced gray matter volume & reduced white matter integrity compared to a healthy adolescent brain.
- Another study used fMRI to measure brain activity and showed that binge drinking during adolescence was associated with lower brain activity, less sustained attention, and poorer performance on a working memory task.
- Research indicates that human brains continue to develop until we are about 30.
- MRI studies show that the gray matter density of most brain regions declines with age; however, gray matter density increases in the left temporal lobe (important for memory and language) until age 30.

Into Adolescence (Cont.)

- Brain development in one's twenties also includes changes in where myelination occurs, which is important for efficiently conducting electrical signals along axons, and myelin protects axons from damage.
- Earlier in life, myelination is found in the visual, auditory, and limbic cortices.
- At 30, the frontal and parietal neocortices (last brain regions to develop) become more myelinated, which helps with working memory & higher cognitive functions.
- The frontal lobe is important for executive functioning (including attention, response inhibition, emotion, organization, and long-range planning).
- The late maturation of the frontal lobe might explain characteristics of a "typical teenager," such as a short attention span, blurting out whatever comes to mind, and forgetting to do homework.

Plasticity

- **Plasticity**: ability of the brain to modify itself and adapt to environmental challenges, including sensory inputs- (w/o it, critical periods would not exist).
- Plasticity is not unique to humans, but our brains' capacity to adapt is a defining attribute of human beings.
- Plasticity is categorized as experience-expectant or experience-dependent.
- Experience-expectant plasticity refers to integrating environmental stimuli into normal developmental patterns.
- Being exposed to certain common or universal environmental experiences (hearing language, seeing faces, or being held) during limited critical, or sensitive, periods of development is essential for healthy brain maturation.
- Experience-dependent plasticity describes continuing changes in the organization and specialization of a person's brain regions as a result of life experiences that are not universal or anticipated.

Plasticity (Cont.)

- These include skills that develop throughout life, with no critical or optimal period for their acquisition (ex: violinists often show greater cortical development in the brain region associated with the fingers of their left hand).
- Using two-photon imaging, scientists found that experience-dependent plasticity occurs not only during critical periods but also during adulthood, so our brains are always changing in response to our experiences, no matter our age.
- Recent insights into brain development hold promise for new treatments of neurological disorders, traumatic brain injury, and learning disabilities, and could help us understand aging as well.
- If scientists can design an approach to manipulating adult plasticity (whether with drugs or with therapies that involve rewiring neural circuits,) it might be possible to correct problems that result from mistimed critical periods.
- A better understanding of normal brain function during each developmental stage could be the key to finding age-specific therapies for many brain disorders.

We hope you enjoyed the workshop!

Any questions?

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