Early Experiences and Brain Development

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Brain Development
Post-Conception to the Third Decade of Life

23 1/2 weeks

27 weeks

Newborn

Adult
## Stages of Brain Development

<table>
<thead>
<tr>
<th>Event</th>
<th>Begins</th>
<th>Ends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell migration</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; prenatal week</td>
<td>6&lt;sup&gt;th&lt;/sup&gt; prenatal month</td>
</tr>
<tr>
<td>Cell differentiation</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; prenatal week</td>
<td>1-2 years postnatally</td>
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<tr>
<td>Synaptogenesis</td>
<td>22 weeks gestation</td>
<td>Late adolescence</td>
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<tr>
<td>Myelination</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; trimester</td>
<td>Middle adulthood</td>
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Prenatal and Early Postnatal

- Exuberant overproduction of
  - neurons
  - synapses
    - newborn has many more synapses than adult brain.
    - prune synapses to adult numbers over early years.
- Allows for maximum adaptability
How we become who we are: biological inheritance & individual experiences

- Genes specify properties of neurons and neural connections to different degrees in different pathways and at different levels of processing.

- Brain circuitry relies on experience to customize connections to serve the needs of the individual.
  - Experience shapes these neural connections and interactions but always within the constraints imposed by genetics.
Basic Principles of Brain Architecture

• Basic information circuits wire first

• Higher circuits build on lower circuits, skills beget skills

• Foundation matters
What shapes brain development?

- Synapse creation and elimination shaped powerfully by experiences
- After repeated stimulation, synapse stabilizes; otherwise it tends to be eliminated ("use it or lose it" principle)
- Pruning/recruitment of synapses occurs in response to experience.
Synapse formation in different areas at different ages

Contributions to Brain Development

- Genetic unfolding of blueprint
- Experience incorporated into the structure of the brain in two ways.
  - Experience expectant development
  - Experience dependent development
Experience expectant development

- **Expected experiences**
  - Patterned light information facilitates the development of
    - low-level visual abilities (e.g., depth perception)
    - high-level visual abilities (e.g., face perception).
  - Complex auditory information facilitates the development of speech and language processing.
  - Availability of a caregiver facilitates the development of attachments.
Experience dependent development

- Unique is to each person
- Active formation of new synaptic connections throughout the life span, based on individual’s interaction with the environment.
  - Remembering events
  - Acquiring vocabulary
  - Quality of attachment
Survival of the Species...

Genetics

Experience Expectant

Experience Dependent

plasticity
Plasticity and Restorative Processes

Birth 10 20 30 40 50 60 70

Normal Brain Plasticity Influenced by Experience

Physiological “Effort” Required to Enhance Neural Connections

Age (Years)

Source: Levitt (2009)
Some circuits develop largely impervious to experience.

For other circuits, the impact of experience on the brain is not constant throughout life—instead experience exerts an especially strong influence at certain times—sensitive periods.

Finally, other circuits remain open to the effects of experience throughout the life cycle.

Early experience often exerts a particularly strong influence in shaping the immature brain.
Absence of the Expectable Environment

Inadequate input (neglect, deprivation)
Excessive/unwanted input (threat/abuse/exposure to violence)

Humphreys & Zeanah, 2015
Effects of adverse experience

Deviations from the expectable environment

Inadequate input
- age-specific reductions in thickness and volume of association cortex
  (overpruning of synaptic connections, lower numbers of synaptic connections reduced dendritic branching)
- reduced performance on tasks that depend on these areas (e.g., complex cognitive tasks)

Harmful input
- hippocampus
  - reduced dendritic spines and arborization
  - reduced functioning
- amygdala
  - elevated activation to emotional stimuli
  - increased vigilance and attention to threat related cues
- vmPFC
  - reduced vmPFC thickness
  - low vmPFC during emotion processing
  - reduced structural/functional connectivity with amygdala & hippocampus

Teicher & Sampson, 2016; McLaughlin & Sheridan, 2014
Deprivation/neglect leads to reduced needed input for normal brain development.
Extreme Neglect Reduces Brain Power

Raised in Families
Raised in Institutions

Marshall & Fox, 2004
Institutional rearing and EEG power are mediated by changes in white matter development

Exposure to Deprivation → White Matter → EEG Alpha and Theta Power

Sheridan et al., 2012
Threat/abuse/violence leads to excessive activation of fear circuitry and stress response systems compromising normal brain development.
Brain regions and pathways involved in regulating response to threatening stimuli overlap extensively with regions found to differ structurally in maltreated individuals: thalamus, visual cortex, anterior cingulate, cortex, ventromedial prefrontal cortex, amygdala, and hippocampus.
Attention bias following threat/abuse or neglect/deprivation

Attention bias away from threat (face) in severely abused children with PTSD

Pine et al., 2005

Reduced attention bias to happy in severely deprived young children.

Troller Renfree et al., 2017
Sensitive periods in brain and behavioral development
Brain is primed for input from the *expectable environment* at certain times.

**Sensitive period:**
- When the effect of experience on the brain is particularly strong during a limited period in development.

**Critical period:**
- A special class of sensitive periods that result in “irreversible” changes in brain function.
Persistence to age 15 years of deprivation specific patterns of impairment

Rutter et al., 2010
Distribution of alpha EEG power across the scalp by timing and group.

CAUG

FCG > 24

FCG < 24

NIG

2.44μV²

3.80μV²
Importance of child caregiver relationships

• Human infants require caregivers’ protection and support to ensure survival for years after birth.

• Relationships with caregivers essential in helping children regulate responses to stressors and adversity.

• THE most important context for child development is child’s relationship(s) with primary caregiver(s).
What builds healthy brains?
Thankyou!

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