Early Brain Development, Early Education, and the Development of Executive Function Skills

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NIH/NICHD

National Institutes of Health

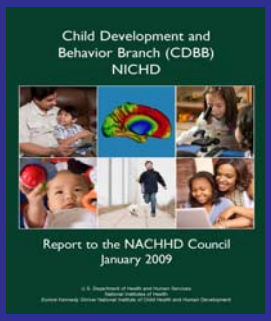
World's largest supporter of biomedical, behavioral, & social science research & training.

Total Budget: $30.5 Billion

Grantees: 80+%

Intramural Research: 10%

Child Development & Behavior Branch

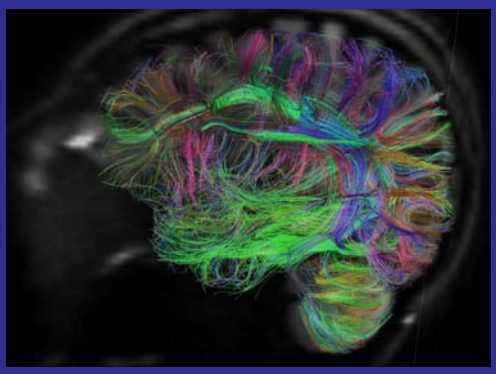


http://www.nichd.nih.gov/crmc/cdb/cdb.htm

Child Development & Behavior Branch

- Early Learning & School Readiness (James Griffin, Deputy)
- Developmental Cognitive Psychology, Behavioral Neuroscience, & Psychobiology (Lisa Freund, Assoc. Deputy)
- Language, Bilingualism & Biliteracy Development & Disorders (Peggy McCardle, Chief)
- Reading, Writing, & Related Learning Disabilities (Brett Miller)
- Math & Science, Cognition & Learning Disorders (Kathy Mann Koepke)
- Pediatric Behavior & Health Promotion (Lynne Haverkos)
- Social & Affective Development, Child Maltreatment & Violence (Valerie Maholmes)
- Human-Animal Interaction (Layla Esposito)

The Brain is Still a Mystery

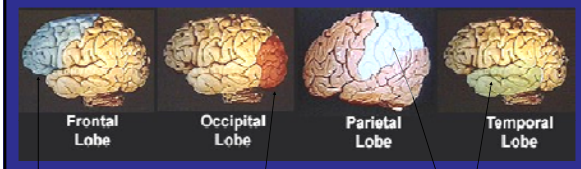


The Human Brain

- Most complex three pounds in the universe
- 100 billion neurons at birth
- 250,000 to 500,000 neurons per minute during some stages of development

"Neurons that fire together, wire together"

Major Areas of the Brain



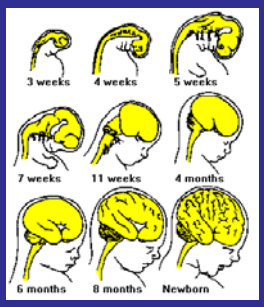
Self-regulation, problem solving, goal setting, social cognition

Vision and perception

Sensory motor perception, spatial abilities

Hearing, language, memory, social - emotional function

Brain Growth

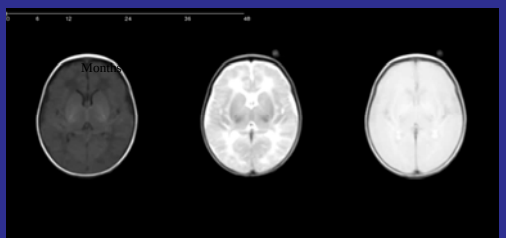


AGE	BRAIN WEIGHT (GRAMS)
20 WEEKS GESTATION	100
BIRTH	400
18 MONTHS	800
3 YEARS OLD	1100
ADULT	1300 - 1400

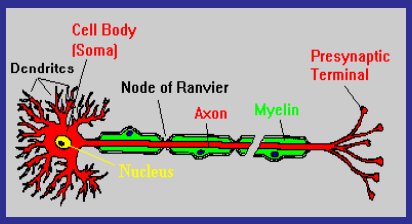
Brain Growth

- At birth, most neurons the brain will have are present
  - approx. 100 billion neurons
- By age 2 years, brain is 80% of adult size
- What keeps growing?
  - Other brain cells (glia)
  - New neuron connections
    - *approx. 1000 trillion connections by age 3 yrs.*

Normal brain growth from 0-54 months



The Neuron



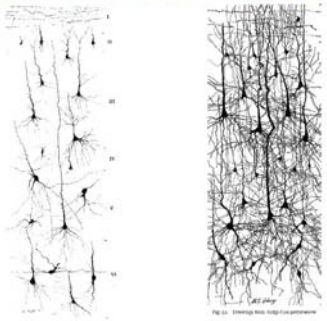
Myelinization

- Speed of connection
- Begins at birth, rapidly increases to 2-years old
- Continues to increase more slowly through 30-years-old

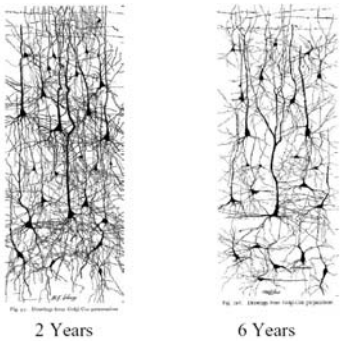
How Does the Developing Brain Become Aware, Learn, Think,?

- Overproduction of neurons and connections among neurons
- Selective reduction of neurons and connections among neurons
- Waves of intense branching and connecting followed by reduction in neurons
  - Before birth through 3-years-old
  - Again at 11- or 12-years-old

Birth to 2 Years--Synapses



2 Years to 6 Years--Synapses



How Brain Function is Developing

- Brain areas with longest periods of growth and pruning
  - self-regulation,
  - problem-solving,
  - language/communication areas
  - Social bonding
- Most vigorous growth, pruning, connecting, and activity occurs between ***1-1/2 years through 3 or 4 years old***
- Neuroscience is telling us that ***this is a crucial period*** for developing self-regulation, problem-solving, social-emotional, and language/communication behaviors

Nature and Nurture

- Genes and environment interact throughout brain development
  - Genes form neurons, connections among major brain regions
  - Environment and experience refines the connections; enhancing some connections while eliminating others

Experience Can Change the Actual Structure of the Brain

- Brain development is "activity-dependent" - every experience excites some neural circuits and leaves others alone
- Neural circuits used over and over strengthen, those that are not used are dropped resulting in "pruning"
- Importance of "plasticity" – we continue to learn throughout our lives, and the brain is able to make new connections after trauma

What early experiences promote healthy brain development?

- Important areas of brain development are
  - Social emotional function
  - Executive function\Self-Control
  - Language/communication
  - Learning
- Research shows that everyday experiences with parent or other adults can optimize the child's development in these areas

Domains of Early Childhood Development

- Executive function and self-regulation
  - Attention, behaviors and emotions\motivation
- Basic components of learning
  - Language, reasoning, problem-solving
- Forming friendships
  - Trust, bonding, resolution of conflicts

Executive Function

- No single accepted definition of EF
  - All agree that the pre-frontal cortex acts as the central "control tower"
  - Core EF skills include ***cognitive flexibility*** (ability to shift focus), ***inhibition*** (self-control and self-regulation) and ***working memory.***
  - Higher order EF skills include ***problem-solving***, ***reasoning*** and ***planning***
  - Role of ***motivation*** and ***emotion***

Executive Function

- EF skills develop with brain maturation
  - Beginnings in infancy
    - Infants at 6 weeks can anticipate sequence of actions
  - 18-months
    - Know when information is ambiguous,
    - "Theory of mind" developing
  - From infancy through 5-year-old develop ability to inhibit and direct behavior

Social Basis of Early Brain Development

- Early Experiences create brain neuron connections
- Parent-child interactions are key
- Progression from secure attachment to self-regulation.

How do nurturing parents and caretakers do this?

- In Infancy, parent often will act out what infant cannot yet do…
  - Physical actions
  - Verbal communication
  - Directing attention

Parent-Child Interaction with Infant or Toddler

- Successful parent/caretaker
  - Is sensitive to child's cues
  - Responds to child's distress
  - Takes advantage of simple, everyday activities to stimulate learning

The Type of Parent-Child Interaction Can Influence Learning and Problem Solving

- Scaffolding with the infant and toddler
  - Directing attention
  - Modeling, instructing
  - Allow child to perform
  - Give feedback
  - Build on the feedback

Parent-child Interaction with 3- to 5-year-old

- Scaffolding with 3- to 5-year-old
  - Directing attention
  - Suggesting strategies
  - Monitoring, evaluating actions
  - Staying directed toward goal
  - Feedback is less directive

Research has Shown that Successful Scaffolding Results in Healthy Brains Ready to Learn

- Faster rates of language learning
- Increased task persistence
- Increased self-control
- More appropriate requests for help
- Increased self-monitoring during tasks
- Increased ability to learn
- Moderates risk factors

Effects of "Toxic Stress"

- Stress hormones can shape the developing circuitry of the brain, especially the prefrontal cortex (the executive function "control tower")
- The psychological stress associated with growing up in poverty can impair early learning abilities, affecting school readiness skills
- Nurturing and supportive home, child care and preschool environments can help buffer this stress and promote adaptive behaviors

Past, Present and Future Research

- Long-term benefits of the Perry Preschool, Abecedarian and Chicago Longitudinal Study interventions linked to EF skill development
- The Family Life Project study of growing up in rural poverty includes direct measures of child stress hormones and EF skill development
- Multiple ongoing school readiness intervention studies examining ways to bolster EF skills
- Two new measures of EF in early childhood

Science August 2011

Special Issue on Early

Childhood Education

Volume 333

For More Information See…

http://www.nichd.nih.gov/about/org/crmc/cdb/

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