

NEURAL DEVELOPMENT AND BRAIN PLASTICITY
A PRÉCIS TO UNDERSTANDING THE EFFECTS OF EARLY ADVERSITY

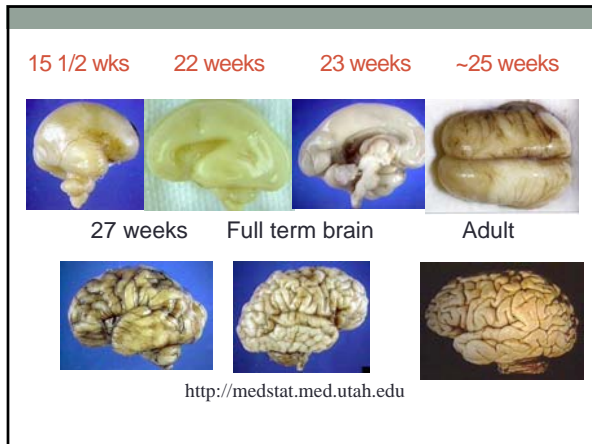
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Talk presented at 23 March 2012, Administration for Children and Families, HHS, Washington, DC

PART I.
INTRODUCTION TO BRAIN DEVELOPMENT

Principles of Brain Development

- *Genetics* supplies basic blueprint for brain development.
- *Experience* adjusts the blue print and shapes the architecture of its neural circuits, according to the needs and distinctive environment of the individual



Stages of Brain Development

- Neurulation (18-24 days post conception) – construction of the neural tube

The diagrams show the progression of neurulation: 1. Neural plate formation, 2. Folding of the neural plate, 3. Fusion of the neural plate edges, 4. Completion of the neural tube, 5. Differentiation of the neural tube into primary vesicles, 6. Further development and folding of the neural tube.

Brain Development Con't

- Neurogenesis (~6th prenatal week – 2nd postnatal year) – create neurons and glia
- Cell migration (6th - 24th prenatal weeks) – construct cerebral cortex

The image shows a dark field with several bright, elongated, and somewhat curved structures, characteristic of neurons or neural fibers in a developing brain.

Brain Development Con't

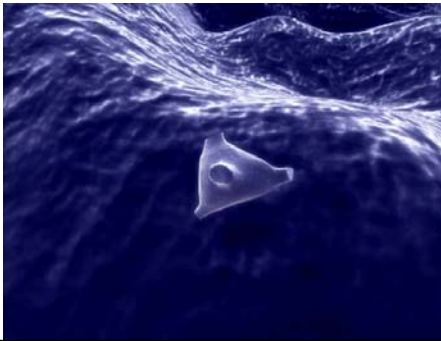
- Differentiation (16th prenatal week-2nd postnatal year) – axons, dendrites mature
- Synaptogenesis (23rd prenatal week – 1+ postnatal year)

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Synaptic Density



Differentiation and Synapse formation



Pruning of Synapses

Following peak (4-6 months in visual Cortex; mid-late adolescence in prefrontal cortex) is gradual pruning of synaptic Population

Pruning heavily dependent on experience

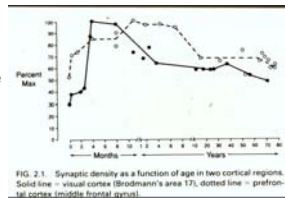
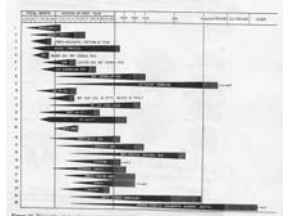


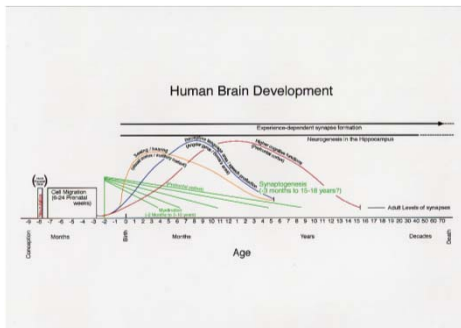
FIG. 2.1. Synaptic density as a function of age in two cortical regions. Solid line - visual cortex (Brodmann's area 17), dotted line - prefrontal cortex (middle frontal gyrus).

Brain Development, Con't

- Myelination (last trimester – middle age) – fatty substance coats axons to increase information transmission

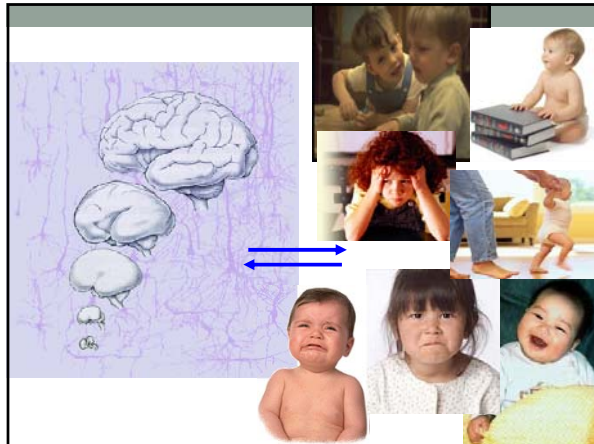


Summary of Brain Development



PART II: NEURAL PLASTICITY

Does the structure of experience work its way into the structure of the brain? How so?



Individuality is the product of both personal experiences & biological inheritance

- Genetics specifies the properties of neurons and neural connections to different degrees in different pathways and at different levels of processing.
- But, because many aspects of an individual's world are not predictable, the circuitry of the brain 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

Experience is the product of an ongoing, reciprocal interaction between the environment and the brain

- Specific experiences vary enormously under identical environmental conditions, depending on the history, maturation, and state of the individual's brain
- Brain maturity has impact on experience:
 - Different areas of the nervous system mature at different rates
 - Lower level processing areas mature earlier than those at a higher level.
 - Thus, a less mature brain is affected largely by more fundamental features of the environment, such as patterned light or the speech train.

Con't

- As the brain matures and changes with experience, more detailed aspects of the environment influence it.
- Thus, as an individual's brain changes, particularly during the early developmental periods, the same physical environment can result in very different experiences.

Conclusions

- I. The impact of experience on the brain is not constant throughout life.
- II. Early experience often exerts a particularly strong influence in shaping the functional properties of the immature brain.
- III. Many neural connections pass through a period during development when the capacity for experience-driven modification is greater than it is in adulthood.
- IV. Such phases are referred to as *sensitive* or *critical* periods.

POSITIVE EXPERIENCES

Influence of Experience Speech and Language Development

- ✗ Between 6 and 12 months, infants move from being able to discriminate phonemic contrasts from most languages, to specializing in discrimination of contrasts from native language
 - + Thus, the perceptual window narrows with experience
- ✗ At 6 months, an infant being reared in an English-speaking home can discriminate the speech sounds of most languages

Speech and Language Development

- Between 9-12 months, they begin to lose this ability (except for English)
- However, if 9 month olds given ~5 hours of exposure to non-native language (by live "tutor"), can recapture this ability
 - But if exposure occurs via audio or videotape, no effects

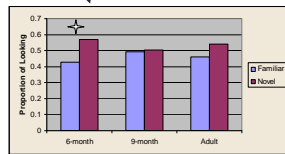
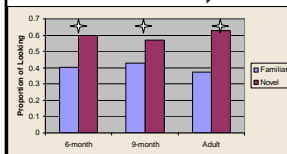
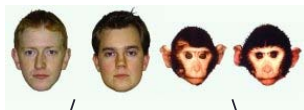
Face Processing

- Evidence that experience plays essential role in development of face processing:
 - Infants who have congenital cataracts removed a few months after birth show remarkable recovery of general visual function but show persistent, subtle deficits in face processing
 - "Other race effect" in which adults are better at recognizing faces from familiar races (generally their own) vs. less familiar races
 - "Other species effect" (see next slides)

Face Processing (Con't):

- "Other species" effect, in which
 - 6 month olds, 9 month olds, and adults can discriminate two human faces but only 6 month olds can discriminate two monkey faces (see next slide)

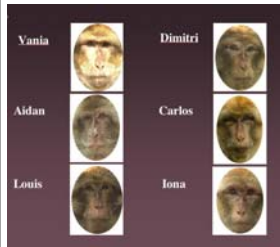
Pascalis, de Haan, & Nelson, 2002



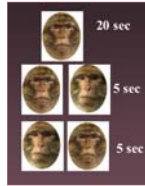
Follow Up Study

- Is it possible to keep open the perceptual window with additional experience?

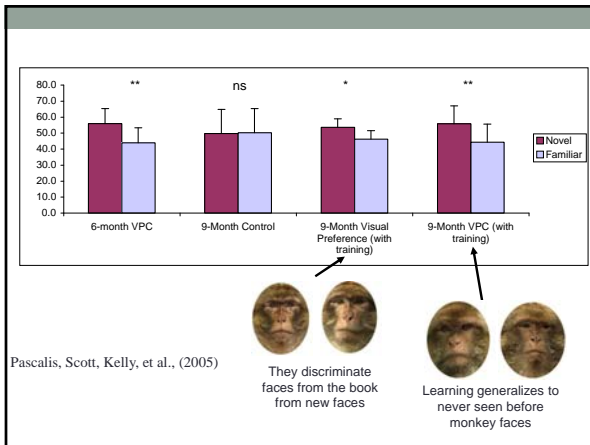
Experiment 1: Training Infants



Pascalis, Scott, Kelly, et al., 2005



- **Visit 1: 6-months**
 - VPC
 - Sent home with monkey face book
- **Visit 2: 9-months**
 - Visual Preference (trained faces)
 - VPC (novel faces)



Pascalis, Scott, Kelly, et al., (2005)



Summary

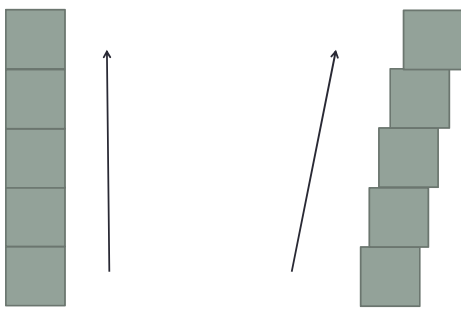
- ✘ Must consider several factors when modeling developmental plasticity
 - + Timing, dose, duration, and type of experience
 - + Developmental status of brain when experience occurred
- ✘ Remember, different experiences will affect different systems differently at different times in development.

WHY IS EARLY DEVELOPMENT IMPORTANT?

Analogous to building the foundation of a house; provides support for all of subsequent development

If initial building blocks are even slightly misaligned, as stack of blocks (i.e., course of child development) grows higher, begins to tilt, misdirecting development

Model of development



THE END
