Kristin Anderson Moore Lecture, Child Trends

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Brain Development, Trauma and Epigenetics – Plasticity as a Pathway to Hope
All human potential lies on a curve

birthweight, athletic ability, musical ability, IQ, EQ, age to walk, talk, read, do math, capacity for joy, etc, etc
Every brain is built like a community

- Cells (neurons) are the building blocks of different structures within the brain
- Nerve fibres/tracts form the highways between them
- Major critical regions are built first, then joined together, then specialized
- Stimulation and activity moulds how strongly each pathway works
- Glia control the brain’s environment – nutrition, clean-up, blood supply
As we learn, each cell in our brain grows new and stronger connections

Kurt Haas, UBC
Sequential periods of brain “development”

OPEN AND SHUT
The human brain’s sensitivity to learning seems to crest in three broad waves. The critical periods for cortical regions devoted to vision and other senses (red) open in infancy, then close tightly. Those for language (yellow) and higher cognition (purple) open later, and never close entirely. The successive waves allow a child to acquire increasingly complex skills (grey text).

Not as OPEN and SHUT as we used to believe!!
Sensitive periods in early childhood brain development

- Pre-school years
  - Vision
  - Hearing
  - Emotional control
  - Numbers, Symbols
  - Habitual ways of responding

- School years
  - Language
  - Peer social skills

High Sensitivity

Low Sensitivity

Years
Imaging the learning brain

Mapping learning

5-20 yrs old
The complications of puberty!

The \textit{average} teenage brain
Allen Institute for Brain Science:
Maps interconnectivity, identity and function of different brain circuits over time (mouse and human)
Right now - in your brain, your own map is changing

- The brain has a powerful ability to change, adapt, and rewire itself throughout life.
- Individual neurons grow, and new ones are added to the active circuits
- It changes how it uses its genetic code, in response to life experiences
- Stimulation, nutrition, exercise, stress, all modify this growth rate of neurons
Brain circuitry changes with activity
How is brain function disrupted by trauma?

- Physical trauma disrupts neural circuit function, releases chemicals that can cause further loss of neurons.
- Trauma also causes glial changes in the brain (some acute and beneficial, some not – and chronic).
- Some of these same changes occur in response to extreme stress, infection, Post-Traumatic Stress Disorder (PTSD).
- Glia impact the brain’s food supply, clean up, immune function, activity level, future ability to respond to signals.
- Neurogenesis (production of new neurons) is also altered.

**SOME PATHWAYS ARE MORE VULNERABLE THAN OTHERS.**
Individual responses to brain trauma vary widely

- With age (children **FAR BETTER** at re-wiring and enhancing plasticity than adults)

- With gender (depends on the type or age of trauma)

- **All individuals can improve** with appropriate immediate and long-term intervention (therapy – occupational, physical, emotional, educational)

- Successful response also depends a great deal on prior experience and state at the time trauma happens (vulnerability vs. resilience)

Each of us carries an epigenetic “signature” of our prior life’s experience that will provide clues to the likely success of a particular intervention, or select the optimal approach.
Epigenetics ("above or in addition to genetics") stands at the center of modern medicine, and is the key to understanding our individuality and potential - because epigenetic changes, unlike DNA sequence can occur rapidly as a result of dietary and other environmental exposures (e.g., stress, drugs, physical activity, obesity, etc.).
Every cell packs its DNA differently

DNA methylation and histone modifications help to compartmentalize the genome into domains of different transcriptional potentials

- Low histone acetylation
- Dense DNA methylation
- H3-K9 methylation

- High histone acetylation
- Low DNA methylation
- H3-K4 methylation

• Explains how cells that all have the same DNA become different from each other
As your brain learns, matures and changes, so does its DNA structure
Epigenetic signatures are changed as a result of:

- Stage of development
- Trauma (physical, emotional, chemical)
- Chronic Infection
- Environmental chemicals
- Drugs of abuse
- Stress/affection
- Exercise
- Diet/nutrition
- Aging

In early childhood development (ECD) and at all ages!!!
Why are identical twins not actually identical?

Asthma
Anxiety
Cancer
Bipolar
From ECD on up, environment makes a difference across the lifespan
The formula for a successful childhood is equally effective across the lifespan
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Understanding and unlocking human potential
Behavioral/intellectual environment can enhance plasticity, neurogenesis, and change epigenetic signatures

NEGATIVE
- Stress
- Inactivity
- Obesity
- Depression
- Neglect
- Trauma
- Drugs of abuse

POSITIVE
- Nutrition
- Stimulation (Sensory, other)
- Exercise
- Activity
- Affection
Now is the time for real hope

A UNIQUE MOMENT IN NEUROSCIENCE

$50-80\text{ M/yr} (~$55M IN 2014)
LAUNCH MARCH 2012
- 10 year plan
- Cell types, connections, circuits, modeling, theory
- Mouse visual system, human
- Single Institution

UP TO €80-100\text{ M/yr} (~€30M IN 2014)
LAUNCH FEB. 2013
- 10 year plan
- Modeling, theory, engineering
- Multiple model systems up to human
- 100+ labs across the world

UP TO $50-100\text{ M/yr} ($40M IN 2014)
IN PLANNING STAGES
- Technology development, cell types, connections, circuits, modeling, theory
- Multiple model systems up to human
- Many labs across the US
Understanding what controls the time windows of sensitivity will require us to combine functional imaging with an understanding of the individuality of each brain cell, and the key epigenetic variations that underlie this. This will guide how we best use the “appropriate” kind of intervention to shift the curve, and allow us to revisit and retrain the most vulnerable and critical pathways to support the well-being of every human being.

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For more information...please go to BrainFacts.org