The Science of Early Brain Development: Opportunities for Prevention/Early Intervention
Translating the Science into Practice

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Your Baby's Brain

NEW RESEARCH

From Jealousy To Joy: How Science Is Unlocking the Inner Lives Of Infants

Eight-month-old Sarah Strub wears a Geodesic Sensor Not for study of facial-emotion recognition
An Accelerated View of Brain Development

15 1/2 weeks

22 weeks

23 weeks

24 weeks

27 weeks

Full term brain  Adolescent  Adult

Adolescent brain (black box)

Ungrateful...talks back...
risk taking...doesn’t
clean room...moody
Summary of Brain Development

Human Brain Development

Experience-dependent synapse formation

Neurogenesis in the Hippocampus

Cell Migration (6-24 Prenatal weeks)

Myelination (2 Months to 5-10 years)

Synaptogenesis (-3 months to 15-18 years?)

Adult Levels of synapses

Age

Conception

Birth

Months

Years

Decades

Death
Making connections: 700 synapses per second!!!!
Neurons to Neighborhoods

...virtually every aspect of early human development, from the brain’s evolving circuitry to the child’s capacity for empathy is affected by the environments and experiences that are encountered in a cumulative fashion, beginning in the prenatal period and extending throughout the early childhood years.”

Shonkoff and Phillips, 2000
Brains are built over time, from prenatal period to adulthood.

Interactions between genes and experience shape brain architecture.

Capacity for change decreases with age.

- Shonkoff 2003
Components of Brain Development
Brain Architecture
Neurogenesis

- Formation of nerve cells.

- Postnatal neurogenesis through at least middle age in dentate gyrus, and possibly some areas of prefrontal cortex and parietal cortex.

- Animals, influenced by experience
  - Learning and exercise increase
  - Stress decreases
Nerve cell or neuron

20 year old male
105,000 miles of axons
Circle the earth x 4
Differentiation
- outgrowth of axons and dendrites from the cell body
- formation of synapses
- synthesis of neurotransmitters

Growth of axons towards their targets is controlled by signaling molecules that act to attract or repel growing axon (e.g., cell adhesion molecules; nerve growth factors).
Formation of Synapses

- First synapses observed about 23rd prenatal week
  - rapid proliferation follows and continues postnatally

- An initial overproduction of synapse
  - newborn brain has many more synapses than adult brain

- Synapse elimination occurs much later
  - e.g., 6 years for visual cortex, 15+ years for PFC
A Synapse

- A SYNAPSE
- Bouton (Foot)
- Vesicles
- Axon
- Mitochondria
- Synaptic Cleft
- Receptor Sites
- Neurotransmitters
- Dendrite of next Neuron
Architectural Principles

• Circuits that process basic information are wired earlier than those that process more complex information.

• Higher circuits build on lower circuits, skills beget skills

• Development of higher level capabilities is more difficult if lower level circuits are not wired properly.
Principles of Brain Development

- *Genetics* supplies basic plan for brain development.

- *Experience* adjusts the genetic plan for the brain and *shapes the architecture of its neural circuits*, according to the needs and distinctive environment of the individual.
  - Experience expectant brain development
  - Experience dependent brain development
What guides brain development?

- Synapse creation and elimination shaped powerfully by experiences
  - Pruning/recruitment of synapses occurs in response to experience.
- After repeated stimulation, synapse stabilizes; otherwise it tends to be eliminated (use it or lose it principle)
- Adaptive for the organism.
  - Maladaptive with abnormal or inadequate input.
Pruning: Use it or lose it

- Experience shapes which synapses are maintained
- At birth – 50 trillion
- At 1 year – 1000 trillion
- At age 20 – 500 trillion
J. McVicker Hunt: “Experience cuts both ways.”
Nature of the experience and maturity of the brain influence risk/benefit effect.
Experience and Neural Plasticity

• Experience

• Result of a complex, bi-directional interaction: environment, developing brain, genes

• Impact of experience on brain is not constant throughout life:
  • in some domains brains are capable of incorporating experience throughout the lifespan
  • But in many domains, early experience often exerts a particularly strong influence in shaping the function of the immature brain; referred to as a sensitive period

• Although sensitive periods are reflected in behaviors, they are actually properties of neural circuits.
Experience expectant development

- Developmental progression in the presence of species-typical experiences/exposures
- Patterned light information facilitates the development of
  - depth perception
  - face perception
- Complex auditory information facilitates the development of speech and language processing.
- Availability of a caregiver facilitates the development of attachments.
Experience-expectant development

- Stereoscopic vision depends on visual cortical regions receiving separate inputs from each eye.
- If 1 eye is deprived of input (cataract, hemangioma, ptosis), ocular dominance columns fail to develop; stereoscopic vision is compromised.
- If not corrected very early $\Rightarrow$ irreversible damage.
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.
  - Learning math
  - Remembering events
  - Acquiring vocabulary
Survival of the Species...

Genetics

Experience Expectant

Experience Dependent

plasticity
Early Experiences

- Crucible of infant experiences are in caregiving relationships
- Nurturing and responsive relationships build healthy brain architecture.
- Absent buffering effects of early relationships, abnormal circuitry may result.
Positive stress

- Typical developmental challenges
- Brief
- Mild–moderate intensity
- Emotional/social/relationship buffers allow return to baseline
  - Knowing what you want but not having words to get it
  - Falling and scraping knee
  - Father leaves the room
  - Starting out of home child care
- POSITIVE STRESS   LACK OF STRESS
Toxic stress or adversity

- Chronic or severe
- Emotional/Social/relationship factors insufficient to serve as buffer
  - Child maltreatment
  - Sequellae of natural disasters
  - Chronic exposure to medical procedures
Toxic Stress

Harvard Center for the Developing Child
By age 3:
- More than half of US children have experienced at least one adverse life event
- 1/3 have experienced more than one
Why early adversity matters

90-100% CHANCE OF DEVELOPMENTAL DELAYS WHEN CHILDREN EXPERIENCE 6-7 RISK FACTORS

Center for the Developing Child
Why early adversity matters

Depression

Felletti et al 1998
Why early adversity matters

Emphysema

Pediatric Pot Pourri 2013
mgleason@tulane.edu
Why early adversity matters

3:1 3:1 ODDS OF ADULT HEART DISEASE AFTER 7-8 ADVERSE CHILDHOOD EXPERIENCES
How Adversity Matters

Accumulation of Adverse childhood experiences

Social, emotional, and cognitive impairment

Adoption of health risk behaviors

Disease, disability, social problems

Early Death

Death

Conception

Gaps in science
Toxic Stress

- Changes brain architecture related to learning, memory, planning, and anxiety
- Causes epigenetic changes, adjusting gene expression and reshaping lifelong stress response
- Encodes changes in neurological, immunological, endocrinological patterns that may emerge later in life

(Suglia et al 2012; Shonkoff et al 2013; Johnson et al 2013)
Research perspectives on brain development
Research With Rhesus Macques

Judy Cameron and colleagues
Heritability estimates

- **Play room test (exploration vs. inhibition)**
  - Latency to leave mom, $h^2=1.0$
  - Time away from mom, $h^2=1.0$

- **Remote-Controlled Car test (approach to novel object)**
  - Vocalizations, $h^2=1.0$

- **Human Intruder test (approach to stranger)**
  - Movement (profile), $h^2=0.54$
  - Movement (stare), $h^2=0.75$
  - Teethgrinding (stare), $h^2=0.89$

- **Novel Fruit test (approach to novel rewarding stimulus)**
  - Latency to inspect, $h^2=1.0$
  - Latency to touch, $h^2=0.74$
Separation from Mother

- 6 months
- 3 months
- 1 month
- 1 week
Early life disruption of mother infant relationship in Macaques

- The type of behavior displayed depends on the *timing* of relationship disruption.

  - *Three month* separated have few abnormalities
  - *One month* separated initially depressed but then *clingy, seek social comfort* when anxious and are *hypervigilant* of social cues.

  - One week separated—no initial reaction— but then *less socially aware, aloof and uninvolved.*
Early life disruption of mother infant relationship in Macaques

- Changes in brain anatomy in the prefrontal cortex
- Lasting changes in gene expression in the amygdala
Can pairing a separated infant with a very attentive mother reverse the effects of early maternal separation?

Does the timing of intervention matter?
Mother Removed

1 wk

Paired with Experienced Mother

...1-3 months

Behavioral Assessments
“Super Mom” results

- Pairing with an experienced mother is more effective when initiated early.
- Critical period of 7 days after which remediation no longer possible.
The **timing** of early adverse life experience plays a critical role in determining brain and behavioral outcomes.

The effects of early life stress last into adulthood, and continue to influence emotion regulation.

Early maternal separation can lead to changes in brain anatomy and gene expression in the brain.

Early intervention can prevent long-term consequences of separation, but the **timing** of intervention is critical.
Caregiving quality and methylation

- 14 children in institution since birth (Russia)
- 14 children raised at home
- Mean age 8 (7–10 yo)
- Measured whole genome methylation
- Higher methylation in institutional group
  - Especially immune responses
  - Cellular signaling (neural communication and brain development)
Hippocampal Volumes (Luby 2013 PNAS)

- Low depression
- High depression

- High support
- Low support

mm³

Pediatric Pot Pourri 2013
mgleason@tulane.edu
Summary of brain development

- Brains are built over time
- Brain architecture and skills are built in a hierarchical “bottom-up” sequence
- Brain plasticity and the ability to change behavior decrease over time
- Experience shapes the architecture
  - Probably through epigenetic processes with lifelong and intergenerational implications
Early brain and child development: Promoting well being
Development

Protective factors
- caregiving relationships
- social class
- IQ

Favorable outcome

Unfavorable outcome
- poverty
- parental mental illness
- parental substance abuse
- abuse/neglect
- teenage parenthood
- low birthweight

Risk factors
Early intervention effects

Change from a high-risk to a low-risk trajectory

Adaptive behavior

Delinquency
Substance abuse
Psychiatric sequellae
School failure
Buffering toxic stress

- Secure access to food
- Safe housing
- Access to health care
- Safe child care
- Trustworthy adult(s)
- SAFE RELATIONSHIPS

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Buffering toxic stress

- Family/community Violence
- Inadequate housing
- Food insecurity
- Parental incarceration
- Parental mental illness
- Environmental hazards
- Chronic illness
Environment

Family/community Violence

Inadequate housing

Food insecurity

Parental incarceration
Environmental hazards

Food insecurity

Family/community Violence

Inadequate housing

Parental incarceration
What About Parenting–Child Relationships?

- Are the foundational relationships in early childhood
- Are influenced by multiple generations of intimate relationships
- Can buffer and protect against genetic and social risks
- Can increase genetic and social risks
- Can worsen under stresses (including child mental health problems)
- Are important targets of early childhood mental health intervention
Ingredients for Healthy Development: a caregiver who is

Always: bigger, stronger, wiser, and kind

Whenever possible: follows the child’s needs

Whenever necessary: takes charge

- Cooper et al 1998
- Circleofsecurity.org
CIRCLE OF SECURITY
PARENT ATTENDING TO THE CHILD’S NEEDS

Secure Base
- Watch over me
- Delight in me
- Help me
- Enjoy with me

Safe Haven
- Protect me
- Comfort me
- Delight in me
- Organize my feelings

Support My Exploration
- I need you to...

Welcome My Coming To You
- I need you to...

Always: be BIGGER, STRONGER, WISER, and KIND.
Whenever possible: follow my child’s need.
Whenever necessary: take charge.

Cooper, Hoffman, Marvin, Powell, 1998; circleofsecurity.org
Attachment Biobehavioral Catch up

- 10 sessions with foster parent and infant/toddler
- Focused on training, psychoeducation, and support in understanding the needs of high-risk infants and young children
- Accurately identifying and interpreting child’s cues and needs
- Outcomes include
  - Decreased rates of disorganized attachment
  - Increased caregiver sensitivity
  - (Dozier 2008, Bernard 2012)
Dozier’s ABC intervention for children in foster care: Cortisol metabolism effects

Bernard et al 2012
Bucharest Early Intervention Project

Study Design

136 Institutionalized Children (6-30 months)

- **NIG**
  - n=72
  - Assessments at 30, 42, 54 & 96 months

- **CAU**
  - n=68

- **FCG**
  - n=68

- **Sf Ecaterina**
- **Sf Andrei**
- **Sf Vasile**
- **Sf Maria Controceni**
- **Giulesti**
Foster Care Intervention

Recruited and trained to fully commit and love the children as their own.
Supported by Tulane clinicians, weekly consultations.

Goal was to have foster care that was:
- Effective
- Affordable
- Replicable
- Culturally sensitive
- Informed by latest findings
Explicitly encouraged foster parents to attach

Frequent contact by BEIP social workers

83% placement stability through 54 months of age

Higher caregiving quality at 30 and 42 months based on observational ratings
Main effects of intervention

Higher IQs
Enhanced expressive and receptive language
Greater height and weight
Reduced stereotypies
More expression of positive emotions
Enhanced competence
More secure and fewer aberrant attachments
Fewer attachment disorders
Less anxiety and depression
Reduced psychiatric symptomatology
More mature and better functioning brains
DQ as a function of age of entry

Age at placement in foster care

DQ/IQ

<table>
<thead>
<tr>
<th>Age</th>
<th>DQ/IQ</th>
</tr>
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<tbody>
<tr>
<td>0-18</td>
<td>95</td>
</tr>
<tr>
<td>18-24</td>
<td>90</td>
</tr>
<tr>
<td>24-30</td>
<td>85</td>
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<tr>
<td>30+</td>
<td>80</td>
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</tbody>
</table>
Distribution of alpha power across the scalp by timing and group

CAUG

CAUG

NIG

2.44μV

3.80μV

C_A

3.80μV^2

2.44μV^2
Distribution of alpha power across the scalp by timing and group

Care as usual

Foster care before 20 mo

Never institutionalized

2.44μV^2

3.80μV^2
Distribution of alpha power across the scalp by timing and group.

- Care as usual
- Foster care after 24mo
- Foster care before 24mo
- Never institutionalized

Values:
- 2.44μV²
- 3.80μV²
Applying EBDD knowledge in practice
Prenatally
- Screen for risk factors especially parent psychopathology, safety, nutrition

Postnatally
- Encourage the experiences that promote brain development

Infancy:
- Talk to baby! “no such thing as spoiling”
- Self care and sleep
- Anticipate stranger anxiety

Toddler
- Routines
- Talk to, read to child
Promoting healthy development

- Promote safe, stable, and nurturing early relationships
  - Talk about parental self care and sleep
  - Encourage talking to baby, responding to communication efforts
  - Encourage predictable routines
  - Praise and motivate positive behaviors
  - Promote safe, predictable, boring discipline
  - Anticipatory guidance should include social-emotional development
    - Stranger anxiety/separation distress at 7–9 months
    - Developing autonomy in toddlerhood
Promoting healthy development: Advocacy

- Promote safe communities
- Support quality early childcare settings
- Adequate access to food and housing
- Access to adult mental health services
Identify at-risk children in practice

(and acknowledge the children with lower risks!)
Observation of the parent child relationship

- Observations of attachment behaviors
  - Seeking proximity?
  - Soothed by parent?
  - Organized approach to being soothed?

- Observations of parenting behaviors
  - Sensitive to child’s needs?
  - Responds to cues?
  - Actively monitoring and engaged with child?
Observing the parent child relationship: High safety/Low stress situation

Cooper, Hoffman, Marvin, Powell, 1998; circle of security.org
High stress/Low safety situation

SAFE HAVEN
- Protect me
- Comfort me
- Delight in me
- Organize my feelings

Welcome My Coming To You

I need you to...

Cooper, Hoffman, Marvin, Powell, 1998; circleofsecurity.org
Healthy high stress, low safety situations: What does it look like?

Parent Behavior

- **Infant**
  - Shows distress around new people or with separation
  - Proximity to parent (or social referencing) resolves distress

- **Parent**
  - Acknowledges infant’s distress
  - Responds to child cues of distress or joy and anticipates needs

Child Behavior
High stress, low safety situations in primary care

- Immunizations!!!

- Physical exams
Red flags: Child observation

- Child avoids parent, resists comfort, or has no clear strategy of seeking proximity
- Proximity to mother does not resolve infant’s distress
- Child averts gaze from parent
- Overly withdrawn and clingy
When proximity ≠ comfort
You’re back, but I’m not looking at you....
Red flags: Parent observation

- Mother resents or rejects comfort-seeking behaviors
- Parent does not respond to child cries or vocalizations
Red Flags

- Parent sounds detached, disinterested, disorganized, or overtly disdainful when talking about infant
- One-sided view of the child (all bad, all good)
- Not engaged in being parent for THIS child?
Red Flags: Parent perception
Validated measures
- Parent depression screens (e.g. PHQ-2)
- Early Childhood Screening Assessment (http://www.infantinstitute.org/measures-manuals/)

Listen to your gut!
- “what is she thinking?”
- “I really want to get out of here”
- When everyone in the office is trying to avoid a parent
Early Childhood Screening Assessment

Child's name

Age in months:

1. Seems sad, cries a lot
   0 1 2
2. Is difficult to comfort when hurt or distressed
   0 1 2
3. Loses temper too much
   0 1 2
4. Avoids situations that remind of scary events
   0 1 2
5. Is easily distracted
   0 1 2
6. Hurts others on purpose (biting, hitting, kicking)
   0 1 2
7. Doesn't seem to listen to adults taking to him/her
   0 1 2
8. Battles over food and eating
   0 1 2
9. Is irritable, easily annoyed
   0 1 2
10. Argues with adults
    0 1 2
11. Breaks things during tantrums
    0 1 2
12. Is easily startled or scared
    0 1 2
13. Tries to annoy people
    0 1 2
14. Has trouble interacting with other children
    0 1 2
15. Fidgets, can't sit quietly
    0 1 2
16. Is clingy, doesn't want to separate from parent
    0 1 2
17. Is very scared of certain things (needles, insects)
    0 1 2
18. Seems nervous or worries a lot
    0 1 2
19. Blames other people for mistakes
    0 1 2
20. Sometimes freezes or looks very still when scared
    0 1 2
21. Avoids foods that have specific feelings or tastes
    0 1 2
22. Is too interested in sexual play or body parts
    0 1 2
23. Runs around in settings when should sit still (school, worship)
    0 1 2
24. Has a hard time paying attention to tasks or activities
    0 1 2
25. Interrupts frequently
    0 1 2
26. Is always "on the go"
    0 1 2
27. Reacts too emotionally to small things
    0 1 2
28. Is very disobedient
    0 1 2
29. Has more picky eating than usual
    0 1 2
30. Has unusual repetitive behaviors (rocking, flapping)
    0 1 2
31. Might wander off if not supervised
    0 1 2
32. Has a hard time falling asleep or staying asleep
    0 1 2
33. Doesn't seem to have much fun
    0 1 2
34. Is too friendly with strangers
    0 1 2
35. Has more trouble talking or learning to talk than other children
    0 1 2
36. Is learning or developing more slowly than other children
    0 1 2
37. I feel down, depressed, or hopeless
    0 1 2
38. I feel little interest or pleasure in doing things
    0 1 2
39. I feel too stressed to enjoy my child
    0 1 2
40. I get more frustrated than I want to with my child's behavior
    0 1 2

Are you concerned about your child's emotional or behavioral development? Yes Somewhat No
Early Identification – II

- Have a plan in place!
- Discuss strengths and concerns with parents
  - “negative” screens provide opportunity to praise and support parents
  - Avoid interpreting
  - Avoid judging
  - Develop a plan for support
  - Emphasize that observations/screens are not diagnostic... refer for an assessment
- Use your local supports!
Early Childhood Mental Health Problems 101

- Are common...
  - 12% of 2–5 year olds’ emotional and behavioral problems get in the way of normal development
  - Anxiety disorders and disruptive behavior disorders are most common

- Persist...
  - Most young children with emotional and behavioral problems will have a disorder up to 4 years later
  - Teacher reports of behaviors at 2 years old predict 75% of children who will have a diagnosis at age 5 (Egger et al 2006; Lavigne et al 2012; Bufferd 2006)
Types of early childhood mental health problems

- Disruptive behaviors
- ADHD
- Post Traumatic Stress Disorder
- Major depressive disorder
- Anxiety disorders
- Autism spectrum disorder
- (limited data regarding bipolar disorder)
Impact of Early Childhood Mental Health Problems

- Child care expulsion
- Family stress
  - Parental self-blame, conflict
  - Family sleep impairment
  - Limited opportunities to use extended family/friend support
- Increased risk of child maltreatment
In office interventions

- Support parenting strengths
- Praise positive child behaviors
- Point out child’s bids for parent attention and response to parent attention
- Acknowledge challenges
- Describe universal child emotional needs
- Define parental self-care as a parenting skill
Incredible years series
CIRCLE OF SECURITY

Parent attending to the child's needs

Secure base
- I need you to...
- Support my exploration
- Watch over me
- Delight in me
- Help me
- Enjoy with me

Safe haven
- Protect me
- Comfort me
- Delight in me
- Organize my feelings
- Always: be BIGGER, STRONGER, WISER, and KIND.
- Whenever possible: follow my child's need.
- Whenever necessary: take charge.

Welcome my coming to you
- I need you to...

Cooper, Hoffman, Marvin, Powell, 1998; circleofsecurity.org
Collaborative models of Care: Co-location of MH professional

- For assessment
- For therapy
- For psychiatry consultation or co-management
  - Associated with decreased sx’s vs care as usual and high rates of satisfaction (Kolko et al, 2011)
Primary care–specific therapies

- **Triple P** *(Bor 2002)*
  - Multi-level intervention to prevent and reduce disruptive behaviors
  - Primary care level model includes nurse-directed

- **Primary Care Parent Child Interaction Therapy** *(Berkowitz 2010)*
  - *Group level, parent intervention*
  - *4 sessions*
Consultation Models

- Consultation models
  - Assessment
  - Treatment recommendations
  - Resource recommendations
    - Associated with decreased access barriers, increased sense of competence, high satisfaction (Sarvet et al 2010)
Useful resources for parents and pediatricians

- AAP.org/ebcd
  - Practice transformation tools
  - Parent information
  - Links to healthy children.org

- Healthychildren.org
  - Useful developmental tools and tips on normative developmental tasks
  - Positive parenting

- Center for social emotional foundations for early learning (Csefel.org)
  - Parent audio and written information

- Zero to three (zerotothree.org)
  - Busy website
  - Best areas are interactive baby brain map (Brain development)
Finding your local resources

- Families Helping Families
- Educational and developmental supports
- Local mental health center
- Call Magellan
- Ask Tulane Infant Mental Health Services (504 988 9184)
Be an informed referrer

- Most referrals to MH services fail the first time
- Assessment should be at least 1 hour and generally more than 1 appointment
- Treatment should involve parents
  - Usually in the room, but definitely aware of the treatment plan, goals, and progress
- Parent management training has strong evidence base for disruptive behavior disorders and some anxiety disorders
- Young children can learn relaxation strategies and reduce trauma symptoms in cognitive behavioral therapy
- Medications should be used only in conjunction with therapy and usually after adequate trial of therapy has failed
Thanks!

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