ENHANCING POSITIVE CHANGE FOR THE DEVELOPING BRAIN

NATHAN A. FOX
DISTINGUISHED UNIVERSITY PROFESSOR
UNIVERSITY OF MARYLAND

NORLIEN - THE IMPORTANCE OF EARLY CHILDHOOD:
SOCIO-EMOTIONAL DEVELOPMENT AND EARLY INTERVENTION
OUTLINE OF TALK

Principles of brain and behavioral development
Sensitive periods

Using the Bucharest Early Intervention Project to illustrate these principles
Implications for policy
Brains are built over time, starting in the earliest years of life. Simple skills come first; more complex skills build on top of them.

Cognitive, emotional, and social capabilities are inextricably intertwined throughout the life course.

A strong foundation in the early years improves the odds for positive outcomes and a weak foundation increases the odds of later difficulties.
The Ability to Change Brains Decreases Over Time

Normal Brain Plasticity Influenced by Experience

Physiological “Effort” Required to Enhance Neural Connections

Source: Levitt (2009)
Neural Circuits are Wired in a Bottom-Up Sequence

Sensory Pathways (Vision, Hearing)

Language

Higher Cognitive Function

Experience Shapes Brain Architecture by Over-Production Followed by Pruning
(700 synapses formed per second in the early years)
Interaction shapes brain circuitry
Serve & Return Builds Brains and Skills

Young children naturally reach out for interaction through babbling, facial expressions, and gestures, and adults respond in kind.

These “serve and return” interactions are essential for the development of healthy brain circuits.

Therefore, systems that support the quality of relationships in early care settings, communities, and homes also support the development of sturdy brain architecture.
Barriers to Educational Achievement Emerge at a Very Young Age

An “Air Traffic Control System” in the Brain

Executive functioning is a group of skills that help us to focus on multiple streams of information at the same time, set goals and make plans, make decisions in light of available information, revise plans, and resist hasty actions.

- A key biological foundation of school readiness as well as outcomes in health and employability.
What are Executive Function Skills?

**Inhibitory Control** — filter thoughts and impulses to resist temptations and distractions

**Working Memory** — hold and manipulate information in our heads over short periods of time

**Cognitive flexibility** — adjust to changed demands, priorities, or perspectives
Building an “Air Traffic Control System” in the Developing Brain

<table>
<thead>
<tr>
<th></th>
<th>Working Memory</th>
<th>Inhibitory Control</th>
<th>Cognitive Flexibility</th>
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<tbody>
<tr>
<td>Adult</td>
<td>Remember multiple tasks, rules &amp; strategies that may vary</td>
<td>Self-control, situationally appropriate responses</td>
<td>Revise actions &amp; plans in changing circumstances</td>
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<tr>
<td>2-5 years</td>
<td>Remember 2 rules (shoes here, coats there)</td>
<td>Delay eating a treat, follow arbitrary rule</td>
<td>Shift actions as rules change</td>
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<td>9-16 months</td>
<td>Execute simple 2-step plan (means-to-end tasks)</td>
<td>Begin to maintain focus despite distractions</td>
<td>Seek alternate methods when 1st attempt fails</td>
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- **Remember multiple tasks, rules & strategies that may vary**
- **Self-control, situationally appropriate responses**
- **Revise actions & plans in changing circumstances**
- **Shift actions as rules change**
- **Begin to maintain focus despite distractions**
- **Seek alternate methods when 1st attempt fails**
Developmental Opportunities for Executive Function Skills

The Marshmallow Test
Higher Childhood Self-Control Predicts Better Adult Health

Source: Moffitt, et al. (2011)
Higher Childhood Self-Control Predicts Greater Adult Wealth

Source: Moffitt, et al. (2011)
Higher Childhood Self-Control Predicts Less Adult Crime

Source: Moffitt, et al. (2011)
Three Core Concepts in Early Development

3 Toxic Stress Derails Healthy Development

NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD
Center on the Developing Child HARVARD UNIVERSITY
Significant Adversity Impairs Development in the First Three Years

Source: Barth, et al. (2008)

Number of Risk Factors

Children with Developmental Delays

20% 40% 60% 80% 100%

1-2 3 4 5 6 7

Number of Risk Factors

Source: Barth, et al. (2008)
TOXIC STRESS DERAILED HEALTHY DEVELOPMENT
Learning how to cope with moderate, short-lived stress can build a healthy stress response system.

Toxic stress—when the body’s stress response system is activated excessively—can weaken developing brain architecture.

Without caring adults to buffer children, toxic stress associated with extreme poverty, neglect, abuse, or severe maternal depression can have long-term consequences for learning, behavior, and both physical and mental health.
The Biology of Adversity: Three Levels of Stress

Positive
Brief increases in heart rate, mild elevations in stress hormone levels.

Tolerable
Serious, temporary stress responses, buffered by supportive relationships.

Toxic
Prolonged activation of stress response systems in the absence of protective relationships.
CHILDREN’S MOTIVATIONS

Extrinsic: Desire to achieve and/or fear of failure

Intrinsic: Motivated by interest

Being rewarded for something you enjoy can actually dampen intrinsic motivation
MOTIVATION IS CRITICAL FOR LEARNING

The anticipation of a future reward boosts dopamine signaling in the brain.

This increase in dopamine...
1. Boosts working memory, enhancing performance over the short-term
2. Reinforces learning, increasing the chances of exhibiting the previously rewarded behavior in the future

When an *extrinsic* reward is delivered over and over, it loses its value & is not as motivating anymore.
CHILDREN’S MOTIVATIONS

**Extrinsic:** Desire to achieve and/or fear of failure

**Intrinsic:** Motivated by interest, curiosity

When children are *intrinsically* motivated to learn, they…

- enjoy the process more (by definition)
- show longer-term retention
- apply their knowledge more often (deep vs. surface learning)
- demonstrate higher academic achievement
- perceive themselves as more competent

Ryan and Deci, 2000; Simons et al., 2004
Playful learning

The ingredients of play are precisely those that *promote learning*:

- *Intrinsically* motivating (fun)
- Opportunity for novel experiences
- Active engagement
- Learning from others
- Strengthening of social bonds
- Stress reducing
IDEAS FOR ENCOURAGING INTRINSIC MOTIVATION

Be playful. This is not a waste of time, as long as the activities are geared towards learning the material.

Be enthusiastic: this reminds children of how much fun learning can be if they enjoy the process rather than focusing on the end-point.

Make clear why material is going to be useful to them (beyond getting a good grade).

Make connections from material to topics that interest them, via analogies or examples.

De-emphasize grades – and explain why (intrinsic motivation is more powerful than extrinsic).

Ryan and Deci, 2000; Simons et al., 2004
CHILDREN’S AND CAREGIVERS’/TEACHERS’ MINDSETS

FIXED Mindset:
Intelligence is a static trait. Some students are smart & some are not

GROWTH Mindset:
Intelligence can be developed through effort & instruction

Carol Dweck
Stanford University
IT PAYS TO HAVE A GROWTH MINDSET

- Significantly raises students’ grades and achievement test scores (Blackwell, Trzesniewski, & Dweck, 2007; Good, Aronson, & Inzlicht, 2003)
- Helps underrepresented students remain engaged and achieve well, even in the face of stereotypes (Blackwell et al., 2007; Good et al., 2003; Aronson, Fried, & Good, 2002)
- Creates a love of learning and a resilience that is essential for great accomplishment

Carol Dweck
Stanford University
HOW DO WE KNOW WHEN TO INTERVENE?

Or when children need to have certain experiences to facilitate growth and development?
SENSITIVE PERIODS

Are limited time periods during which the effect of experience on the brain is particularly strong

Allow experience to instruct neural circuits to process information in an adaptive way

Provide information that is essential for normal development and may alter performance permanently
Lorenz and imprinted ducklings walking after him
Hubel and Weisel: Classic studies on early experience and sensitive periods

Monocular deprivation in early infancy led to deficits in brain organization in visual cortex
Studies of infants born with bilateral cataracts—timing of surgical removal

Effects of unilateral and bilateral deprivation of patterned vision (Lewis & Maurer, 2005)
Sleeper effects as a function of sensitive period input

Early experience establishes the neural substrate for capabilities that emerge at a much later point in development.

14 years later children whose cataracts were removed late in infancy were deficient in face processing.

Sleeper effects

Daphne Maurer,1,2 Catherine J. Mondloch3 and Terri L. Lewis1,2,4
Sensitive Periods for Integration of Auditory and Visual Information

Eric Knudsen studies Barn Owls manipulating their early visual or auditory experience identifying sensitive periods for these inputs.
A sensitive period for language in the visual cortex: Distinct patterns of plasticity in congenitally versus late blind adults

People blind from birth hear language in their visual cortex
The timing and nature of experience with language affects perception of different languages.

Before 9-10 months of age, infants can discriminate the sounds of all languages. By the end of the first year of life, they are only able to discriminate the language(s) they hear in their environment.

Janet Werker

Effects of experience on perception of language (Werker & Tees, 2005)
Multiple sensitive periods across development for different domains

Most probably there are different sensitive periods for different skills across the first years of life

FIGURE 4  A cartoon illustrating the cascade of influences involving different components of the overall speech-processing system. Each component has a different optimal period and a different pattern of selectivity. Moreover, experientially induced changes in each component influence both later emerging and previously developed components.

Werker & Tees (2005)
Can we reopen sensitive periods in the visual system?

The answer appears to be yes!!

CRITICAL PERIOD PLASTICITY IN LOCAL CORTICAL CIRCUITS

Takao K. Hensch

Abstract | Neuronal circuits in the brain are shaped by experience during ‘critical periods’ in early postnatal life. In the primary visual cortex, this activity-dependent development is triggered by the functional maturation of local inhibitory connections and driven by a specific, late-developing subset of interneurons. Ultimately, the structural consolidation of competing sensory inputs is mediated by a proteolytic reorganization of the extracellular matrix that occurs only during the critical period. The reactivation of this process, and subsequent recovery of function in conditions such as amblyopia, can now be studied with realistic circuit models that might generalize across systems.

(Hensch, 2005)
Collectively, in most cases sensory/perceptual development proceed normally if such systems are “set” correctly during a sensitive period of development—(e.g. Hubel and Wiesel)

There is also evidence for sensitive periods in specific domains of language and perception.

The human brain “expects” certain types of input at particular times in development.

It is not clear what aspects of cognitive or social and emotional development require experience at particular (e.g., sensitive) points in time. Inferences drawn from intervention studies suggest some advantage to early experience.
Questions?

Coffee Break?
The Bucharest Early Intervention Project seeks to:

- Examine the effects of psychosocial deprivation on brain and behavioral development of young children

- Determine if these effects can be remediated through intervention, in this case: foster care

- Examine the issue of timing of intervention or duration of deprivation and its effects on brain and behavior with an eye towards identifying sensitive periods in cognitive and social development
Project Background
CEAUSESCU’S LEGACY TO ROMANIA

• Raise production by increasing population
• Establishment of the MENSTRUAL POLICE - state gynecologists who conducted monthly checks of women of childbearing age who had not borne at least 5 children
• Establishment of CELIBACY TAX - families received a stipend for having more than 2 children; were levied tax for having fewer than 5 children
• OUTLAWED all contraception and abortion
THE RESULTS OF CEAUSESCU’S 1966 POLICY

• Child abandonment became a national disaster, as families could not afford to keep their children, and were encouraged to turn them over to the state. This destroyed the family unit and led to thousands of children being raised in institutions.
1989: The fall of the Ceausescu regime
The aftermath....

100,000 children “warehoused” in state institutions

- Poverty #1 reason for child abandonment
- International media brought the plight of these children to the attention of the world
- Large numbers of children adopted internationally, often by Western families unprepared for challenges that lay ahead
- And then, Romania banned international adoption
The Study
After baseline assessment (pre-group assignment), comprehensive follow up performed at 30, 42, 54 months, 8 and 12 years.
DOMAINS OF ASSESSMENT IN BEIP

- Physical Development
- Language
- **Cognition**
- Language
- Brain Function
- Emotional reactivity
- Caregiving Environment
- **Attachment**
- Social competence
- Mental Health Problems
- Genetics

*Data derived from measures listed in **bold** and underlined will be discussed in this talk*
GENERAL HYPOTHESES OF THE BEIP STUDY

• Institutional rearing will have profound effects upon children’s socio-emotional development

• Removing children from the institution and placing them in family environments will remediate some of these deficits.

• The age or timing of placement into foster care will be a significant factor explaining intervention effects (thought this may vary by domain)
COGNITION AND LANGUAGE
COGNITIVE DEVELOPMENT
(AT BASELINE)

Smyke et al (2007)
IQ Scores of Foster Care and Institutionalized Groups at Follow-up

How does IQ differ for children in foster care as a function of age of placement?

Age of Placement and Language Skills at 42 months of age: Effects of timing

[Bar chart showing the comparison of expressive and receptive language skills for different age groups of foster placement.]

- IG (Intact Group)
- FC>29m (Foster Care over 29 months)
- FC>24m (Foster Care over 24 months)
- FC>16m (Foster Care over 16 months)
- FC<15m (Foster Care under 15 months)

Reynell z score vs Age of foster placement.
Syntax & Semantics from 42-month language samples

Bar graph showing the mean MLU (morpheme count) at 42 months for different groups:
- IG (n=21)
- FCG>25m (n=10)
- FCG<20m (n=7)
- NIG (n=5)
BRAIN ACTIVITY-EEG

Beta 10-18 Hz
Alpha 6-9 Hz
Theta 3-5 Hz
Delta <3 Hz
INSTITUTIONALIZATION & BRAIN ACTIVITY

Theta, 3-5 Hz

Institution

Community

Proportion

0.58

Marshall, Fox, and BEIP (2007)
INSTITUTIONALIZATION & BRAIN ACTIVITY

Alpha, 6-9 Hz

Institution
Community
Proportion

Marshall, Fox & BEIP group (2007)

McLaughlin et al, 2010, Biological Psychiatry

0.58
0.46
Brain Activity (EEG) Changes as a function of intervention and timing (8 years of age)

Vanderwert et al (2010)
BASELINE DIFFERENCES: 11-31 MONTHS
BEIP: SSP CLASSIFICATIONS

Community
- 76.7% secure
- 3.6% avoidant
- 0.0% resistant
- 19.7% disorganized
- 0.0% unclassifiable

Institution
- 16.8% secure
- 4.7% avoidant
- 0.0% resistant
- 65.4% disorganized
- 13.1% unclassifiable

Zeanah, et al 2005
CONTINUUM OF ATTACHMENT

5 -- ABCD patterns of attachment
4 -- Patterns of attachment with behavioral anomalies
3 -- Clear preference but passive
2 -- Preference discernible
1 -- No attachment behaviors evident
# Degree to Which Children Living in Institutions Have Formed Attachments to Their Caregivers

<table>
<thead>
<tr>
<th>Attachment Level</th>
<th>Romanian Community</th>
<th>Romanian Institution</th>
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<tbody>
<tr>
<td>1=No attachment</td>
<td>0%</td>
<td>9.5%</td>
</tr>
<tr>
<td>2=Some differentiation</td>
<td>0%</td>
<td>25.3%</td>
</tr>
<tr>
<td>3=Some preference</td>
<td>0%</td>
<td>30.5%</td>
</tr>
<tr>
<td>4=Attachment with anomalies</td>
<td>0%</td>
<td>31.6%</td>
</tr>
<tr>
<td>5=Clearly recognizable attachment patterns</td>
<td>100%</td>
<td>3.2%</td>
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Zeanah et al (2005)
Intervention Effects at 42 Months
EFFECTS OF INTERVENTION ON SECURITY OF ATTACHMENT

Smyke et al (2010)
Security of attachment as a function of age of entry

Percent Securely Attached

- 7 to 18
- 18 to 24
- 24 to 30
- 30+

The graph shows that the security of attachment is highest for individuals aged 18 to 24, significantly higher than for those aged 7 to 18 and 24 to 30. The percentage decreases further for individuals aged 30 and above.
SUMMARY OF SSP FINDINGS

Large differences at baseline IG vs. NIG
- Security
- Organization

- Large intervention effects, but incomplete recovery

Timing effects on security and organization
- More children secure if placed before 22-24 months
- More children organized earlier they were placed
DOMAINS WITH SENSITIVE PERIOD

IQ
Attachment
EEG power
Social skills (teacher report)
Indiscriminate behavior

DOMAINS WITH NO SENSITIVE PERIOD (BUT INTERVENTION EFFECTS)

Psychiatric outcomes (anxiety)
Positive emotional reactivity
Peer social competence
DOMAINS SEEMINGLY UNAFFECTED BY EARLY ADVERSITY

Face processing
Emotion recognition
Face recognition

DOMAINS UNAFFECTED BY INTERVENTION

Externalizing problems
Executive function
IMPLICATIONS FOR POLICY

Brains develop as a function of expected environmental experience

In the absence of expected experience brain and behavioral develop are derailed

Children living in conditions of neglect are likely to suffer from the absence of stimulation (warm, responsive, contingent interaction)

Removing children from conditions of neglect (and the earlier the better) is good for their brain development and good for their behavioral development
INVESTIGATIVE TEAM

Principal Investigators
Charles Zeanah, MD, Tulane University
Nathan A. Fox, Ph.D., University of Maryland
Charles A. Nelson, Ph.D., Harvard Medical School/Children’s Hospital Boston

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Romania's Abandoned Children

Deprivation, Brain Development, and the Struggle for Recovery

Charles A. Nelson, Nathan A. Fox, and Charles H. Zeanah

The implications of early experience for children's brain development, behavior, and psychological functioning have long absorbed caregivers, researchers, and clinicians. The 1989 fall of Romania's Ceausescu regime left approximately 170,000 children in 700 overcrowded, impoverished institutions across Romania, and prompted the most comprehensive study to date on the effects of institutionalization on children's well-being. Romania's Abandoned Children, the authoritative account of this landmark study, documents the devastating toll paid by children who are deprived of responsive care, social interaction, stimulation, and psychological comfort.

Launched in 2000, the Bucharest Early Intervention Project (BEIP) was a rigorously controlled investigation of foster care as an alternative to institutionalization. Researchers included 136 abandoned infants and toddlers in the study and randomly assigned half of them to foster care created specifically for the project. The other half stayed in Romanian institutions, where conditions remained substandard. Over a twelve-year span, both groups were assessed for physical growth, cognitive functioning, brain development, and social behavior. Data from a third group of children raised by their birth families were collected for comparison.

The study found that the institutionalized children were severely impaired in IQ and manifested a variety of social and emotional disorders, as well as changes in brain development. However, the earlier an institutionalized child was placed into foster care, the better the recovery. Combining scientific, historical, and personal narratives in a gripping, often heartbreaking, account, Romania's Abandoned Children highlights the urgency of efforts to help the millions of parentless children living in institutions throughout the world.

Charles A. Nelson is Professor of Pediatrics and Neuroscience at Harvard Medical School. Nathan A. Fox is Distinguished University Professor, Department of Human Development and Quantitative Methodology, at the University of Maryland. Charles H. Zeanah is Sellers Polklow Professor of Psychiatry at Tulane University.