

The effects of early life adversity on brain and behavioral development

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Our genes supply the basic blueprint for brain development, but experience *adjusts* the underlying brain circuitry based on the unique environment in which each individual lives.

As the brain changes, particularly during early development, the same physical environment can result in vastly different experiences. Moreover, the impact of experience on the brain is not constant throughout life—early experience often exerts a particularly strong influence in shaping the functional properties of the immature brain. We refer to such time windows as *sensitive* or *critical* periods.



We would like to think that all young children are exposed to nurturing, supportive, stimulating environments, however, this is not always the case. There are countless numbers of young children worldwide who are exposed to adverse early experiences that can have an enormous and life-long impact on the developing brain. In fact, exposure to early adverse life events can weave their way into the developing brain and, depending on their timing, exert powerful and potentially long-term effects on neural structure and function. Such experiences ultimately influence the course of human development.

CHILDHOOD ADVERSITY

Adverse childhood experiences are important determinants of psychiatric disorders, with effects that persist across the life course. Exposure to maltreatment, environmental deprivation, family violence, and parental instability (criminal behavior, substance abuse) has lasting detrimental effects on mental health. Retrospective studies consistently identify higher rates of these childhood adversities among individuals with a psychiatric disorder, and prospective data confirm these associations.

Importantly, childhood adversities are associated with new disorder *onsets* in adulthood, even after accounting for the effects of early-onset disorders, as well as greater chronicity and severity of lifetime mental disorders. The effect of adverse childhood effects on brain development is clear. So-called “toxic stress” early in life can lead to fundamental changes in several regions of the brain, including those that subserve learning and memory (e.g., hippocampus) and those that subserve executive functions (e.g., various regions of the prefrontal cortex).

DEPRIVATION

Much of what we know about the effects of experience on brain development comes from studies with animals, where experiences are altered (e.g., raised in isolation vs. raised in an enriched environment) or absent (e.g., an animal made blind or deaf to examine the role of visual or auditory input on development). Studying the absence of experience on *human* development is obviously more challenging. Here one typically takes advantage of so-called “accidents of nature,” such as a child who is born with limited or absent vision or hearing. An even more dramatic example of early deprivation, however, can be found in studies of children raised in bleak institutions.

Most institutions for abandoned children are characterized by marked psychosocial, linguistic, and sensory deprivation, and their effects on child development are profound. Elevated psychiatric morbidity among previously institutionalized children is particularly striking. One of the most likely explanations for the wide range of developmental problems observed among children exposed to institutional rearing is that the deprived environment of an institution does not provide adequate experience to scaffold normal brain development.

Recent studies employing both EEG and MRI-based imaging tools have led to a number of insights

regarding the link between early deprivation and atypical brain development:

1. Across several studies involving both previously institutionalized and currently institutionalized children, it appears that early severe deprivation leads to a dramatic reduction in overall brain volume (both grey and white matter). Importantly, placement into a family can lead to some (although incomplete) recovery of white matter; unfortunately, the effects on grey matter appear more permanent.

2. There is also an effect of institutionalization on the integrity of white matter fibers, with dramatic losses seen in select areas among previously institutionalized children.

3. Dramatic reductions in the brain's electrical activity (EEG) are observed among currently institutionalized children *and* among previously institutionalized children who were placed in families after 2 years of age; however, among previously institutionalized children placed *before* age 2, EEG activity begins to resemble that of never institutionalized children by 8 years of age (see Figure 1). Overall, a history of institutionalization appears to affect both the anatomy and physiology of brain development.

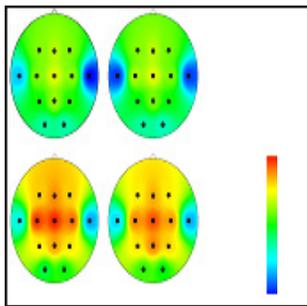


Figure 1 – in these so-called “false color maps” we illustrate the brain’s electrical activity at rest (resting EEG). To orient the reader, these head plots are viewed from the top, looking down. Each small dot represents an EEG sensor. As the color shifts from blue to red the amount of brain activity is increasing. The upper left figure illustrates brain activity at 8 years of age among children randomly assigned to remain in institutional care; the upper right illustrates the brain activity of children who were randomly assigned to foster care after the age of 24 months of age. The lower left plot illustrates the EEG of children randomly assigned to foster care before 24 months of age and the lower right the EEG of never institutionalized children. There are no differences between the two upper plots nor between the two lower plots, indicating that the EEG of children placed in foster care before 2 years of age leads to a profile of brain activity virtually identical to that of never institutionalized children; conversely, the EEG of children placed after 2 years of age (upper left) is virtually identical to that of children who never left the institution (upper right).¹

What relevance do these patterns of neural function have for psychopathology? Here we can draw from the Bucharest Early Intervention Project (BEIP).

The BEIP is a randomized controlled trial of foster care as an intervention for early institutionalization. Three groups of children have been studied through 12 years of age, beginning in infancy. These include children abandoned to institutions and then randomly assigned to remain in institutional care or be placed in high-quality foster care, and a group of never institutionalized children who live with their families (see <http://www.bucharestearlyinterventionproject.org/>). Two recently published studies from this project identified specific patterns of neural function that are associated with mental health outcomes in children exposed to institutionalization. For example, both the pattern of resting EEG activation (the background brain electrical activity generated at rest) and the event-related potential profile during facial processing tasks (the time-locked brain’s electrical activity generated in response to pictures of faces presented on a computer monitor) observed in this sample are associated with symptoms of attention-deficit/hyperactivity disorder (ADHD).

IMPLICATIONS

The Economic and Psychological Upside to Early Intervention

In the BEIP we demonstrated that a simple intervention – placing children in families instead of leaving them in an institution – benefited many domains of development, particularly if the placement occurred early in the child’s life (generally before the age of 2). The observation that early intervention was more efficacious than later intervention is consistent with other work on early intervention. For example, it is well established that social disparities in both educational achievement and in health emerge early in development and increase throughout childhood.

A number of economists have estimated that the economic benefits of intervening early vs. late are quite high; for example, the [HighScope Perry Preschool Study](#) in which children were randomly assigned to a different preschool environment, was associated with differences in both adult income and in adult health behavior.

A second argument in favor of early intervention is that even short-term change may be cost-saving. Treating a preschooler who is consistently inattentive or disruptive may not only benefit the child’s educational performance, it may also have a positive impact on the child’s teacher and parents. For example, the teacher can devote more time to teaching

and the parents less time managing their child's behavior and more time parenting...and working.

Finally, the strongest argument in favor of early intervention is neural plasticity. Early identification of a problem behavior can lead to early intervention, the success of which hinges on the brain's ability to be molded by experience. And, this plastic period may correspond to a sensitive period. As a result, *not* intervening early will represent a missed opportunity.

For example, both intervention and prevention programs to reduce substance use/dependence among teens have low success rates. In contrast, programs or clinical interventions implemented during early childhood can decrease the likelihood of adolescent substance use. It may be that interventions such as these are effective because they affect neural development during a time of maximal plasticity, allowing modifications to the brain's developmental trajectory.

Speaking of the Child Protection System...

There are tens of thousands of children in the child protection system in the United States. If young children remain in neglectful or abusive homes for too long, the risk of long-term harm is great. Thus, it is imperative that we place the child's best interests as our highest priority, and we need to be mindful of the science that underlies child development – that children require consistent, sensitive caregiving *from the start*, and that past the age of 2 years, poor caregiving quality (not to mention outright abuse or neglect) is increasingly likely to deleteriously affect child development.

Implications for Health

Children experiencing early adversity, including institutional care, do not only suffer psychologi-

cally; their health may also suffer. In the BEIP, for example, we have demonstrated that the physical growth of institutionalized children was compromised, and they had shorter telomeres (an index of cellular integrity, and perhaps a predictor of lifespan). We also know that children who grow up with mothers suffering from major depression show alterations in brain structure during childhood. Thus, early adversity not only impacts psychological development, it can also impact biological development and health.

Conclusions

The science is now **unambiguous** regarding the short- and long-term hazards of early life adversity - both psychological and neural development can be compromised. A healthy society hinges on the healthy development of its children, and a concerted effort should be made to protect our children whenever possible from exposure to early adversity. Here the evidence is clear: reduce the levels of toxic stress in children's lives; for parentless children, raise them in families, not institutions; and pay heed to timing – the earlier in life a child is removed from a toxic environment and placed in a supportive environment, the better.

¹. Vanderwert RE, Marshall PJ, Nelson CA, Zeanah CH, & Fox NA (2010). Timing of intervention affects brain electrical activity in children exposed to severe psychosocial neglect. *PLoSOne*, 5(7), 1-5

Further Reading

National Scientific Council on the Developing Child working papers http://developingchild.harvard.edu/resources/reports_and_working_papers/

Nelson, C.A., Furtado, E.A., Fox, N.A., & Zeanah, C.H. (2009). The deprived human brain. *American Scientist*, 97, 222-229.