Critical Periods Revisited: Implications for Intervention With Traumatized Children

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Over the past decade there have been significant advances in the establishment of evidence-based treatments for traumatized children.[1] Severely and multiply traumatized children, however, often have complex and difficult-to-treat clinical presentations. There is a perception among many clinicians, foster parents, and child protective service workers that these children are irrevocably "damaged"—especially when the trauma occurred during early developmental "critical periods." The goal of this article is to review recent advances in neuroscience that debunk the myth that early severe adverse rearing experiences lead inevitably to bad outcomes and to discuss the clinical implications of this evolving work.

The belief that early deviant experience can lead to permanent changes in brain development and behavior stems partly from the groundbreaking experiments on monocular deprivation in cats by Wiesel and Hubel.[2] The development of central visual pathways in several mammalian species is known to be experience-dependent. Wiesel and Hubel deprived kittens of vision in one eye for different lengths of time and at different ages. They found that after suturing one lid during the first 3 months of life, there was no vision in that eye later in development after the sutures were removed, and the visual cortex did not develop normally. The effects of visual deprivation on subsequent brain development and visual processing was evident only in kittens, not in adult cats, which led to the conclusion that vision development in kittens has a "critical period," and if the eyes are not exposed to the required stimuli during that period, vision would be lost and associated brain structures altered permanently.

This finding has been extrapolated to traumatized children, generating the notion that severe adverse early child rearing experiences can lead to permanent alterations in brain development in regions associated with stress reactivity and emotion processing and cause chronic and treatment-resistant psychopathology.[3] Emerging findings, however, are refining concepts of "critical periods" and challenging previous understandings of the impact of early experience on brain development and behavior. Further studies revisiting the initial experiments of Wiesel and Hubel have shown that the effects of monocular deprivation can be reversed with pharmacologic interventions and environmental enrichment.[4] What was previously deemed to be permanent brain damage secondary to adverse early experiences during formative periods of development has now been shown to be amenable to treatment, allowing complete function to be restored.

The emerging research suggests there are sensitive periods when the brain is more susceptible to environmental inputs, early experiences can have enduring effects, but the effects are amenable to change. The concept of "critical periods"—developmental stages when certain experiences are essential for normal development, and failure to obtain these experiences can lead to permanent alterations in brain development and behavior—has been replaced with the concept of "sensitive periods"—developmental stages when certain experiences exert greater influence on brain development and behavior, but brain development and behavior continue to be malleable. So, how do early adverse rearing experiences exert relatively enduring and stable effects on brain development and behavior? How can these effects be reversed? And what are the implications for clinicians working with traumatized children? These questions are explored on the following pages.

HOW DO EARLY ADVERSE REARING EXPERIENCES EXERT RELATIVELY ENDURING AND STABLE EFFECTS ON BRAIN DEVELOPMENT AND BEHAVIOR?

Although there is much left to be learned, animal studies have been key in beginning to unravel the molecular mechanisms by which adverse early rearing experiences can lead to long-term changes in brain development and behavior.[4] These studies have shown that the brain responds to stress in an orchestrated manner. The hypothalamic–pituitary–adrenal axis initiates the stress response and promotes the release of glucocorticoids (e.g., cortisol). Although there are many brain structures involved, the hippocampus is critical for putting on the breaks using glucocorticoid receptors that promote a cascade of events that help to turn off the body's response to stress.

Studies by Meaney and colleagues[5,6] with rodents have shown that "neglectful" parenting is associated with a smaller number of glucocorticoid receptors in the hippocampus, increased stress reactivity, and anxiety and depression-like behaviors in adult offspring of neglectful dams. These long-term and enduring consequences of "neglectful" early rearing appear to be mediated by epigenetic mechanisms. Epigenetic mechanisms play a key role in the acute regulation of genes in response to changes in the environment. Epigenetics refers to functionally relevant modifications to the genome that do not involve a change in the DNA nucleotide sequence. The human genome contains 3 billion nucleotide base pairs that are organized into 23 chromosome pairs. Each chromosome contains approximately 1,000 genes packaged into condensed coil-like structures called chromatin. When the genes are densely packed, they cannot be accessed or transcribed—the gene product cannot be made. Epigenetic modifications to the DNA alter chromatin packing and affect the likelihood of a given gene product being made.

DNA methylation is one of the most studied epigenetic mechanisms. DNA methylation leads to gene silencing by changing the physical configuration of the DNA so a given gene cannot be accessed. The study by Meaney and colleagues[6] found that "neglectful" early rearing experiences are associated with increased methylation of the glucocorticoid receptor gene in the hippocampus. This results in fewer glucocorticoid receptors being made. Because these receptors are key in initiating the cascade of events that put the breaks on the stress response, offspring of "neglectful" dams have increased stress reactivity and consequently exhibit anxious and depression-like behaviors.

CAN THE NEGATIVE EFFECTS OF EARLY ADVERSE REARING BE REVERSED?

Studies with rodents have shown that the negative effects of adverse early rearing experiences can be reversed with subsequent ideal "foster care" parenting and exposure to environmental enrichment during adolescence.[4] These experiences are associated with normalization of the hypothalamic–pituitary–adrenal axis stress response and reversal of the behavioral deficits associated with early adverse rearing conditions. It is important to highlight that even experiences in adolescence—experiences outside the "sensitivity period"—can reverse the biobehavioral changes elicited by adverse early experiences. The window of opportunity for intervention is wider than originally conceived.

WHAT ARE THE IMPLICATIONS FOR CLINICIANS WORKING WITH TRAUMATIZED YOUTH?

The availability of a caring and stable parent or alternative guardian is one of the most important factors that distinguish abused individuals with good developmental outcomes from those with problems.[4] With this in mind, interventions with infants, toddlers, and preschoolers in foster care have been designed to enhance parent–child relationships.[7] Dozier's intervention for maltreated infants and toddlers focuses on improving the caregivers' ability to detect signals of distress from the child and to teaching them to respond sensitively, even if the child appears rejecting of the parents' efforts to comfort the child. Fisher's intervention for preschoolers in foster care emphasizes teaching foster parents to respond consistently and contingently. Both interventions have been associated with improvements in hypothalamic–pituitary–adrenal axis function, attachment, and behavioral outcomes in children. These finding suggests that neuroendocrine changes secondary to early life adversity are responsive to intervention.

In terms of enrichment experiences, in a recent study of matched samples of foster care alumni,

young adults from an enhanced foster care program had significantly fewer psychiatric problems than young adults from public-sector foster care programs.[8] Youth in the enhanced foster care program received tutoring and enrichment opportunities such as participation in summer day camp programs, music and dance lessons, and financial support for postsecondary education. The placements in the enhanced foster care program were also more stable, and caseworkers in the model program had higher levels of education and salaries, smaller caseloads, and. as noted above, access to a wider range of ancillary services than caseworkers in the public programs.

Exposure to adversity early in life can be associated with a wide array of psychiatric problems. As discussed in this article, however, negative consequences are not inevitable. The availability of evidence-based treatments and reconceptualizations of "critical periods" have altered former dire prognostic predictions for these youth. Promoting the development of stable positive caregiving relationships and other enriching experiences can help to tip the scale in favor of positive outcomes. Although there is more to be learned to optimize the outcomes of the most traumatized children, there is good reason for hope. &

Accepted July 27, 2011.

This article was reviewed under and accepted by Ad Hoc Editor Charles H. Zeanah, M.D.

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This work was supported by the Leon Levy Foundation (N.W.), T32 MH067763 (N.W.), R01MH077087 (J.K.), the National Center for Posttraumatic Stress Disorder-Veterans Affairs Connecticut (J.K.), and the VA Depression Research Enhancement Award Program (Veterans Affairs Connecticut; J.K.).

Disclosure: Dr. Kaufman has served as a consultant for Bristol-Myers Squibb, Pfizer, Wyeth-Ayerst, Forest Laboratories, Johnson and Johnson Research Pharmaceutical Institute, Shire, Otsuka, and Merck Pharmaceutical. Dr. Weder reports no biomedical financial interests or potential conflicts of interest.

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0890-8567/$36.00/©2011 American Academy of Child and Adolescent Psychiatry

DOI: 10.1016/j.jaac.2011.07.021

REFERENCES

1. Silverman WK, Ortiz CD, Viswesvaran C, *et al.* Evidence-based psychosocial treatments for children and adolescents exposed to traumatic events. J Clin Child Adolesc Psychol. 2008;37:156-183.
2. Wiesel TN, Hubel DH. Effects of visual deprivation on morphology and physiology of cells in the cats lateral geniculate body. J Neurophysiol. 1963;26:978-993.
3. Perry BD, Pollard P, Blakey T, Baker W, Vigilante D. Childhood trauma, the neurobiology of adaption, and "use-dependent" development of the brain: how "states" become "traits" impact mental health. Infant Ment Health J. 1995;16:271-291.
4. Kaufman J, Weder N. Neurobiology of early life stress: evolving concepts. In: Martin A, Scahill LS, Kratochvil C, eds. Pediatric Psychopharmacology: Principles and Practice. 2nd ed. New York: Oxford University Press; 2010:112-123.
5. Meaney MJ. Maternal care, gene expression, and the transmission of individual differences in stress reactivity across generations. Annu Rev Neurosci. 2001;24:1161-1192.
6. Zhang TY, Meaney MJ. Epigenetics and the environmental regulation of the genome and its function. Annu Rev Psychol. 2010;61:439-466, C431-C433.
7. Fisher PA, Gunnar MR, Dozier M, Bruce J, Pears KC. Effects of therapeutic interventions for foster children on behavioral problems, caregiver attachment, and stress regulatory neural systems. Ann N Y Acad Sci. 2006;1094:215-225.
8. Kessler RC, Pecora PJ, Williams J, *et al.* Effects of enhanced foster care on the long-term physical and mental health of foster care alumni. Arch Gen Psychiatry. 2008;65:625-633.