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Developmental trajectories of abuse – An hypothesis for the effects of early childhood maltreatment on dorsolateral prefrontal cortical development

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ABSTRACT

The United States has a high rate of child maltreatment, with nearly 12 in 1000 children being victims of abuse or neglect. Child abuse strongly predicts negative life outcomes, especially in areas of emotional and mental health. Abused children are also more likely than their peers to engage in violence and enter the juvenile justice system, as well as to become abusive parents themselves. Research has shown that child abuse and trauma can lead to decreased hippocampal volume, which could be indicative of abnormal hippocampal development. Hippocampal development appears to directly affect the development of the dorsolateral prefrontal cortex, a brain area responsible for emotion regulation, cognitive reappraisal, and general executive function. Therefore, I hypothesize that if child abuse results in abnormal hippocampal development, which leads to abnormal dorsolateral prefrontal cortex development, many of the correlated risk factors of child abuse, such as emotionally-laden parenting and unfavorable cognitive distortions regarding children's behaviors, may be in part caused by underdevelopment or abnormal functioning of the dorsolateral prefrontal cortex, as a function of the individual's own experiences with abuse during childhood. If this hypothesis is supported with future research, more targeted, successful, and cost-effective prevention and treatment protocols could ensue. For instance, programs that have been empirically shown to increase the activity of the dorsolateral prefrontal cortex, such as cognitive behavioral therapy, could be effective in decreasing the incidence of intergenerational transfer of abuse.

Introduction

Nearly 12 of every 1000 children in the United States are victims of child abuse or neglect [5]. Most child maltreatment occurs among very young children, with 42.6% of maltreatment cases involving children less than one year of age. Much research has shown that emotional and mental health outcomes for children who experience childhood abuse are worse than for those who did not experience abuse. For instance, maltreated children are significantly more likely than non-maltreated children to engage in violent acts and enter the juvenile justice system [10]. Thus, the phrase "the abused becomes the abuser" has entered into mainstream society. Though it is far from the truth that every child who experiences abuse will go onto abuse his or her own children, there is ample evidence that a history of childhood abuse in one's own childhood is strongly correlated with unskilled and emotionally-laden parenting, and in some cases, abusive or neglectful parenting [8]. Therefore, it is of vital importance that we understand mechanistically how a parent's history of child abuse in his or her own childhood can lead to that parent becoming abusive toward his or her children later on.

Hypothesis

The hippocampus has often been implicated as a brain area of interest when considering the effects of trauma and abuse. The hippocampus is responsible for memory formation and retrieval, and has recently been thought to relate to emotional processing and response [2]. In a normally developing brain, the hippocampus finishes most of its development well before the onset of puberty, often around 4 years of age. A longitudinal study conducted by Gogtay and colleagues of healthy children and adolescents showed that though the hippocampus does not change in overall volume after age four, there is region-specific alteration in hippocampal volume through early adulthood [7]. Decreased hippocampal volume has been observed in several neuropsychiatric conditions, including Post-Traumatic Stress Disorder [16]. Decreased hippocampal volume has also been observed in individuals who suffered childhood trauma and abuse. For instance, a review by Glaser indicates that some children who have experienced trauma or abuse in

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early childhood exhibit decreased hippocampal volume, which may be indicative of stunted hippocampal development [6].

The dorsolateral prefrontal cortex (dlPFC) does not finish development until an individual is an adult [11]. Its development is one of the most protracted of all brain regions, which makes it highly vulnerable to neurological insult. The development of the dlPFC is impacted by the development of the hippocampus, presumably through the connections of the hippocampus to the striatum to the prefrontal cortex [12]. The dlPFC is responsible for regulation of several subcortical regions, such as the amygdala and the striatum, and is also directly involved in working memory, cognitive reappraisal, planning and task execution.

Abnormal functioning of the dlPFC has been correlated with several neuropsychiatric illnesses, such as schizophrenia [15]. Decreased dlPFC functioning can lead to dysregulation of subcortical systems, such as the corticostriatal and corticolimbic circuits, which can result in aberrant behavior. Decreased dlPFC functioning has been correlated with increased aggression, emotional reactivity, and poor impulse control in adults [4].

Based on these findings, I propose that the relationship between childhood trauma and its effects on the development of the hippocampus, with its cascade effect on the development of the dorsolateral prefrontal cortex, could in part explain why the intergenerational transfer of abuse is observed in some families. Research indicates that hippocampal development may be stunted by early childhood trauma and abuse [6]. Therefore, it seems logical that stunted hippocampal development caused by childhood trauma or abuse could lead to stunted dlPFC development, since the hippocampus impacts the development of the dlPFC. I hypothesize that this stunted dlPFC development and function partially explains why some parents who themselves experienced child abuse later abuse their own children. Without a fully developed dlPFC, these individuals may not be able to regulate certain emotional impulses or cognitively reappraise their own children's behaviors, both of which are factors which have been long cited as risks for abusive parenting [3]. Sub-optimal development and functioning of the dlPFC could also lead to dysregulation of the limbic and striatal systems, which could in part explain why some abusive parents exhibit other risky behaviors more often than their peers, such as unhealthy alcohol and drug intake (see Fig. 1).

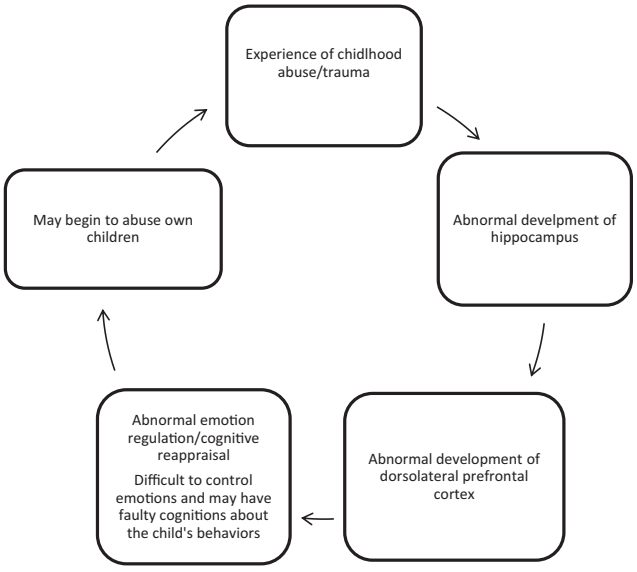

Fig. 1. Hypothesized cyclical nature of abnormal dorsolateral prefrontal cortex development caused by abuse, and effects in some individuals.

Evidence and evaluation

There is increasing evidence that early childhood trauma and abuse can lead to abnormal hippocampal volume and function, and that the development of the dlPFC may depend on proper hippocampal development, though the underlying biological and chemical mechanisms of these pathways are yet to be fully understood [6,12]. Meanwhile, experiments should be conducted to determine if improper hippocampal development caused by childhood abuse does in fact lead to abnormal dlPFC development and function, and if it is in part this dlPFC dysfunction that leads some parents with a history of abuse in their own childhoods to abuse their own children later on. Longitudinal neuroimaging studies would be beneficial to examine why some individuals who experience child abuse become abusive parents themselves, and why others do not. For instance, preliminary studies have shown that females who experienced childhood sexual abuse exhibit smaller hippocampi and attenuated cortical development when compared to females who did not experience childhood sexual abuse, but that the degree of structural impairment depended on the victim's age at the time of abuse [1]. If the hypothesis above is correct, we would expect to see more functional damage to the hippocampi of abusive parents than parents who were abused but who do not abuse their own children, as well as sub-optimal dlPFC functioning in the abusive parent group. If incomplete development of the dlPFC is in fact causally related to child abuse, we would also expect to see improper dlPFC functioning across multiple domains, such as working memory, not just in contexts involving the individual's children.

Much of the research relating to child abuse and its subsequent effects is done with individuals who have developed Post-Traumatic Stress Disorder or who experienced severe forms of physical or sexual abuse. Fortunately, not all children who experience abuse develop PTSD. However, by solely devoting attention to the extreme forms of abuse and its impacts, we cannot draw conclusions about how less severe child abuse and trauma, or emotional abuse compared to physical abuse, might affect the brain and the individuals who suffered these types of maltreatment. Therefore, conducting functional neuroimaging and longitudinal studies focusing on the dimensional aspects of abuse and trauma will be essential in decoding the bigger picture of the intergenerational transfer of child abuse.

However, even if this hypothesis were to be supported in the future with experimentation and refinement, it does not comprehensively inform all the reasons child abuse occurs. For the purposes of this hypothesis, we focus our attention on how the dorsolateral prefrontal cortex relates to the intergenerational transfer of abuse. Although other cortical areas may be implicated in this pathway, I hypothesize that the dlPFC is the most relevant. The dlPFC is responsible for the highest level of cognition and executive function, in comparison with the ventromedial prefrontal cortex (vmPFC), ventrolateral prefrontal cortex (vlPFC), and dorsomedial prefrontal cortex (dmPFC). In many cases of child abuse, a parent must first perceive that a child's behavior is worthy of an abusive response. Abusive parents are often not able to control their anger or fear in responding to their children, perhaps because of cortical dysregulation of these systems. Likewise, they are often unable to cognitively reappraise their child's initial behavior that triggered the parent's abusive response. This is likely due to sub-optimal activation of the dlPFC resulting in insufficient cognitive reappraisal. Although the other prefrontal cortical regions, such as the vmPFC, vlPFC, and dmPFC, also help regulate behaviors and contribute to executive function, they do not seem to contribute to planning/execution and cognitive labeling/reappraisal as significantly as the dlPFC. Finally, sub-optimal dlPFC functioning has