

Research Question: To what extent are developing brain areas affected by childhood physical trauma?

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Introduction:

There are 2.9 million cases of childhood abuse reported each year, with this number being so big it was compelling to research more into how long-lasting trauma can lead to effects on developing brain areas in children (Cohut, 2017). The brain areas implicated in stress response include the amygdala, hippocampus, and prefrontal cortex. The amygdala, hippocampus, and prefrontal cortex are crucial developing brain areas in children and when constant fear and stress occur those brain areas start to become damaged. These brain areas regulate emotion, memory, and cognitive behavior which is vital for children and their development. Psychology has shown how important these brain areas are and how their development is crucial for their function and connectivity with other brain areas. In one study done by J. Douglas Bremner (2006) on traumatic stress and the effects on the brain, he aimed to explain the hormones and neurotransmitters released during stress and how that affects the amygdala, hippocampus, and prefrontal cortex (Bremner, 2006, p. 1). His method for doing this was to test on animal subjects and examine the various parts of the brain and if PTSD changed them. Results showed a smaller hippocampal and anterior cingulate volumes, increased amygdala function, and decreased medial prefrontal/anterior cingulate function (Bremner, 2006, p. 1). The significance of this is that it shows the great effect trauma can have on these brain areas. It also uncovers how harmful cortisol is and how it creates a domino effect on the pathways to the hippocampus and amygdala. Ultimately making the brain predisposed to being in a constant state of flight or fight. This leads to the question, to what extent are developing brain areas affected by childhood physical trauma? This is worth investigating because of how

prominent physical abuse in children is in the United States and how vulnerable the developing brain in children is. Important terminology that will be used in this paper includes the following terms. The amygdala, which is located in the temporal lobe and plays a key role in processing emotion, and forms part of the limbic system. The hippocampus is embedded in the temporal lobe and is an important part of the limbic system, a cortical region that regulates motivation, emotion, learning, and memory. The prefrontal cortex in the cerebral cortex covers the front part of the frontal lobe, it is implicated in planning complex cognitive behavior, personality expression, decision-making, and moderating social behavior. The limitations of this essay will be that I will only be researching physical abuse in children and its effect on the amygdala, hippocampus, and the prefrontal cortex. In my research question, the research done includes multiple studies on the effects of trauma on developing brain areas in children. Already it can be seen that there is a great extent that developing brain areas can be affected by childhood physical trauma.

The Amygdala:

The amygdala is crucial for children and their developing brains. Emotion is a key part of childhood because it leads to understanding and recognizing their feelings towards people and things. Emotion also goes with action signals for example fight or flight. When a child undergoes constant stress such as suffering from physical abuse, the size of the amygdala grows in size. The amygdala changes in size due to stress because the brain has to become more receptive to the stress. Hormones such as cortisol gets released in large amounts of overtime causing changes to

the amygdala. It, therefore, becomes hyperactive in its response to stress, resulting in changes in size and its function. Which in turn causes the neural connections to grow and become more sensitive with constant stimulation (Bergland, 2013).

To show how much the amygdala is affected in long term stress is in a study done by psychologists Jedd, Hunt, Cowell, Rogosch, and Thomas on the long-term consequences of childhood maltreatment. The study aimed to process a functional magnetic machine that examines task-based activation of the amygdala in adults compared to adults who had been maltreated. The method for this study was to take 33 maltreated adults and 38 normal adults matched well in demographics, and then examine the amygdala size and function of the two groups. The results showed that severe childhood maltreatment is associated with lasting alterations in the amygdala (Jedd et al., 2015). The amygdala's size was much different than those of adults who had not suffered from any trauma. The significance shows that childhood trauma can lead to damage in the amygdala which can be life long and cause many other issues down the road. New technology is revealing physical brain changes, seen through MRI's, that the brain goes through when there has been long-lasting trauma in childhood. The study shows that out of about 30 adults who have suffered from maltreatment and 38 who haven't had any long-lasting maltreatment in their childhood there were obvious brain changes in the amygdala and in connectivity with the hippocampus and prefrontal cortex (Jedd et al., 2015). The study proves that the amygdala along with the hippocampus and prefrontal cortex were the brain areas that underwent the most change. Not only will the amygdala change physically which can lead to issues down the road but also its connectivity with other brain areas which can hinder

higher-level abilities. Psychologists Pechtel, Lyons-Ruth, Anderson, and Teicher did a study on the sensitive periods of the amygdala that supports the notion that the amygdala is indeed vulnerable to stress during childhood. This study aimed to examine the results of early stress and the amygdala volume in adults who suffered from trauma in childhood. The method was to take 18 participants and 33 from a cross-sectional control in where they completed a structural magnetic resonance imaging scan (Pechtel et al., 2014). The results showed through the scans that the amygdala may have developmentally sensitive periods in preadolescents leading to changes in its size and therefore function (Jedd et al., 2014). The significance of this is that childhood trauma is detrimental in the development of the amygdala, which is important in developing children. Childhood abuse goes much further than just damaged brain areas, it leads to lifelong behavioral problems and emotional issues. Both shrinkage and growth in the amygdala can cause issues.

Christopher Bergland explains a Stanford study that examined the size and connectivity of the amygdala. This study aimed to examine how a larger amygdala can lead to higher anxiety. The method was to take laboratory animals and put them in a high-stress environment to determine if the amygdala grew additional synapses which would lead to chronic anxiety. The results found that this high-stress environment did increase the synapses and did cause the animals to have anxiety (Bregland, 2013). The significance is that high stress and trauma can lead to more than just a dysfunctional amygdala and start to affect your emotional health. “Studies of laboratory animals placed in an environment causing chronic stress have determined that the animals' amygdala grew additional synapses and that this synaptic connectivity resulted

in chronic anxiety. [...] sustained anxiety can lead to disabling conditions such as phobia, post-traumatic stress disorder (PTSD) and generalized anxiety disorder,”(Bergland, 2013). A highly connected amygdala is usually associated with an enlarged amygdala as well. A highly connected or enlarged amygdala leads to more mental health issues like chronic anxiety and PTSD. The determining factors on whether after long-lasting trauma the amygdala grows or shrinks in size is dependent on a lot and produces mixed results. Basic dependent factors that would influence the size of the amygdala are genetic determinants and environmental modulators (Morey et al., 2013). Whether the amygdala grows or shrinks in size due to physical trauma during childhood, it can still lead to cognitive and mental health issues. Examples of mental health issues that are a consequence of a damaged amygdala are anxiety, autism, depression, post-traumatic stress disorder, and phobias (Science Daily, p.1).

With any research question, there are strengths and weaknesses to it. There are many strengths to this question. For example, it provides deeper research on the amygdala and the effect trauma has on it. It also is uncovering new groundbreaking discoveries like what exactly causes the amygdala to either grow or shrink in size. As for some weaknesses, there is a lack of knowledge about the direct effects on the amygdala from trauma. Trauma affects everyone in different ways, so other factors sometimes play a part in the results of the studies. Another weakness includes ethical issues with neuroimaging (MRI's) in which children are not commonly examined in such ways. Adults are the ones having their brain examined and although the studies included both traumatized and non-traumatized participants, there are still other

things that can happen in life that could contribute to the change in the amygdala of a participant physically abused during childhood.

After considering all the studies and research done it clearly shows that the amygdala was greatly affected by childhood physical trauma. However, there are some issues with the research. For instance, the correlation studies evaluating the brain through MRI's can only be done with adults because it's an ethical issue to study that in children. This can lead to possible other factors causing changes in the amygdala other than just the childhood trauma. The genders were not revealed in the studies making it difficult to see if gender influenced the functioning and changes of the amygdala. Even though there were some flaws with the studies and research it still supports the thesis that developing brain areas are affected to a great extent by childhood physical trauma. This effect leading to the functioning and physical changes in the amygdala, and as a consequence behavioral, cognitive, and mental health issues.

The Hippocampus:

Another crucial developing brain area during childhood that is vulnerable to physical abuse and trauma is the hippocampus. The hippocampus is so important in children's developing brains because it's a key component in learning, memory, and stress response. The hippocampus aids children in growing and developing, especially in school, so when it is damaged or starts to change it can have lasting effects on the child into adulthood. Whether it's learning and memory difficulties or mental health issues the hippocampus is greatly affected by childhood physical

trauma. Both the right and left side of the hippocampus consolidate semantic memory and encode verbal and visual-spatial memories, respectively, it's also been recently shown that it has a specialized role in processing emotions (Bremner & M, 1998). When there is a presence of physical abuse causing long-lasting stress there are physical changes that begin to occur in the hippocampus. Long term stress comes with the frequent occurrence of stress hormones being released such as dopamine, epinephrine (also known as adrenaline), norepinephrine (noradrenaline), and cortisol. When there is the constant firing of these hormones they begin to hinder the hippocampus's ability to receive enough energy by diverting glucose levels to surrounding muscles, which starts to shrink the hippocampus (Bremner & M, 1998). Stress alters the synaptic plasticity and firing properties of hippocampal neurons, the long-lasting stress changes the neuronal morphology, suppresses neuronal proliferation, and then begins to reduce the hippocampal volume (Kim et al., 2015). Over time with prolonged stress due to physical trauma during childhood the hippocampus can begin to shrink which can lead to issues ranging from learning to mental health problems. Although most of the hippocampus is mature by 15 months it is the most vulnerable to stress between 3 to 5 years (Teicher et al., 2012).

To start, I'll examine a study evaluating childhood trauma resulting in a smaller hippocampal volume. Psychologists Vythilingam, Heim, Newport, Miller, Anderson, Bronen, and Bremner aimed to examine volumes of the hippocampus and the control of brain regions with abused and nonabused children during childhood. The method included 32 women with depression 21 with a history of childhood abuse and 11 with no history of depression or abuse. The results showed that the abused participants had an 18% smaller hippocampus than non

abused participants (Vythilingam et al., 2002). The significance is to show that trauma does affect the hippocampus and impairs its functioning as well. “Preclinical studies have confirmed that chronic psychosocial stress and cortisol administration inhibits neurogenesis in the dentate gyrus (8–10) and cause atrophy or remodeling of the apical dendrites of the pyramidal neurons in the CA3 region of the hippocampus,” (Vythilingam et al., 2002). The study confirms exactly what is trying to be proved, it shows that chronic stress such as physical abuse inhibits the production of neurons in the dentate gyrus which is just a part of the hippocampus. This inhibition causes remodeling of the apical dendrites, which conduct electrical messages to the neuron cell body for the cell to function, ultimately changing the hippocampus (Vythilingam et al., 2002). In the following study “Childhood maltreatment is associated with reduced volume in the hippocampal subfields” by Teicher, Anderson, and Polcari they examine how childhood maltreatment is a major factor in mood, anxiety, psychotic, and substance abuse disorders. This study aimed to examine how consistent abuse during childhood leads to a smaller hippocampal volume and the hippocampal subfields. The method included 193 unmedicated participants from the community of subjects who scored high on the Childhood Trauma Questionnaires (Teicher et al., 2012). The results showed that maltreatment was associated with 4.2% and 4.3% reductions in the hippocampal subfields; left presubiculum and subiculum (Teicher et al., 2012). The significance of all of this is that “These findings support the hypothesis that exposure to early human stress in humans [...] affects hippocampal subfield development” which in turn can cause major cognitive problems (Teicher et al., 2012). Providing support for the thesis that childhood physical abuse does indeed affect the hippocampus in this case by shrinking it in size. Physical abuse during childhood leads to a smaller hippocampus which in consequence can lead to

cognitive and mental health issues. When there is intense prolonged stress many hormones are released one of them being glucocorticoids which are very crucial in producing alterations in hippocampal functioning which in turn can contribute to psychopathologies. “Glucocorticoids, as mediators of the myriad effects of stress effects on the hippocampus and as contributing factors to stress-associated psychopathologies such as post-traumatic stress disorder (PTSD),” (Kim et al., 2015). Glucocorticoids released with stress over a prolonged amount of time shrinks the hippocampus which in consequence contributes to anxiety, PTSD, depression, schizophrenia, and drug relapse. Also, a smaller hippocampus can alter cognitive processes like learning and memory. Supporting the thesis that physical abuse and childhood trauma greatly affect the hippocampus in its development and function.

There are strengths and weaknesses found in researching the effect of the hippocampus in childhood physical abuse. The strengths of this research question concerning the hippocampus are that the studies highlight the importance of hormones and their effect on the hippocampus. It also supports how trauma can greatly affect the hippocampus and lead to other issues later in life, revealing possible causes of more severe mental issues. However, there are some weaknesses in the research. The controversy lies in the nature and source of a smaller hippocampal volume. This raises the question if whether the volumetric differences represent the consequence of traumatic exposure or a pre-existing trait that predisposes people to pathological stress reactions to a traumatic event (Gilbertson et al., 2002). This is a weakness to the research question because there still needs to be more research done on the exact cause of volumetric differences in the

hippocampus. Nevertheless, the studies still support that changes in size and function can be due to traumatic exposure.

After reviewing the research and studies used to support the claim, the research shows that developing brain areas like the hippocampus are affected to a great extent by childhood physical trauma. It shows that the hormones released during stress have a great effect on the hippocampus causing it to shrink in size after prolonged exposure to stress, as well as, causing cognitive and mental health issues. Although the research proves and supports the thesis there are some issues with the studies. There were some gender considerations, in one study focusing on the mental health issues associated with a damaged hippocampus focused on women suffering from major depression. This study only focuses on women but was not used to a great extent in the analysis of research. I would conclude that was the only issue, nonetheless, still does support what the thesis is claiming.

Prefrontal Cortex:

The prefrontal cortex is the last to develop in the brain which makes it the most vulnerable to trauma. The prefrontal cortex is important because it deals with planning complex cognitive behavior, personality expression, decision making, and moderating social behavior which is all needed in daily life. Although this brain area does not develop during childhood the other brain areas play a key role in its later development. “Prolonged stress exposure causes architectural changes in prefrontal dendrites. Recent research has begun to reveal the

intracellular signaling pathways that mediate the effects of stress on the PFC (Arnsten, n.d.). For instance, the amygdala and hippocampus play a critical role in the prefrontal cortex's development and function. So if the amygdala and hippocampus are damaged during childhood then the prefrontal cortex will not develop and function correctly. "All of these abilities depend on proper PFC neuronal network connections, which are highly sensitive to their neurochemical environment" (Arnsten, n.d). The amygdala, hippocampus, and prefrontal cortex all work with each other, in childhood where there is long-lasting stress the coordination of nerve networks become damaged and an adaptation of trauma becomes a state of mind.

When having undergone childhood physical abuse it's often that the hippocampus has a smaller volume, there's an increase in amygdala function, and decreased prefrontal cortex function. When changes have been made to the amygdala and hippocampus they function in a way that then, in turn, affects the prefrontal cortex's role. In a study "Traumatic stress: effects on the brain" by Bremner (2006), "Shin and colleagues found a correlation between increased amygdala function and decreased medial prefrontal function with traumatic reminders, indicating a failure of inhibition of the amygdala by the medial prefrontal cortex that could account for increased PTSD symptoms with traumatic reminders" (Bremner J. D., 2006). After prolonged stress on the amygdala it no longer can function correctly, an increase in its use subsequently decreases the prefrontal cortex's function. Childhood trauma leads to the brain areas not working with each other and in some cases against, "Under conditions of psychological stress the amygdala activates stress pathways in the hypothalamus and brainstem, which evokes high levels of noradrenaline (NA) and dopamine (DA) release. This impairs PFC regulation but strengthens

amygdala function, thus setting up a ‘vicious cycle’” (Arnsten, n.d). It's a never-ending cycle that the brain goes through once critical brain areas have been damaged. When the amygdala is damaged there's no chance of the prefrontal cortex developing and functioning correctly which supports just how much these brain areas are affected by childhood trauma. Just like the amygdala, the hippocampus does not assist the prefrontal cortex as it should in a normal brain. The amygdala and hippocampus have wired the prefrontal cortex to always be in a state of survival mode, therefore, impacting and affecting a person's ability to be calm, learn, think, reflect and respond flexibly. As seen in changes to the amygdala and hippocampus a damaged prefrontal cortex comes along with its set of mental and cognitive issues. “The reduction in PFC functioning that occurs during stress is highly relevant to understanding human mental and physical health. Loss of self-control during stress exposure can lead to a relapse of several maladaptive behaviors, such as drug addiction, smoking, drinking alcohol and overeating [...] major risk factor for depression [...] post-traumatic stress disorder (PTSD) [...] also exacerbate the symptoms of schizophrenia and bipolar disorder” (Arnsten, n.d). A myriad of issues come along with a prefrontal cortex not functioning correctly. When examining childhood physical trauma there's many lifelong consequences and affected brain areas that will not connect and function correctly, ever.

Many strengths came out of this research. One of them is a new way to look at the importance of the brain areas and how they work together, and that trauma doesn't just affect the area itself but its ability to connect through neural networks. It also points out important upcoming research that, “highlights how genetic and environmental changes in stress signaling

pathways are associated with mental illness, and how an understanding of these pathways might lead to better treatments for neuropsychiatric disorders” (Arnsten, n.d). The research done for the effects on the prefrontal cortex strengthened the thesis made by showing the larger picture by how once one area during childhood is damaged it's a domino effect for the other brain areas. Weaknesses of this research would have been that it looked at a lot of different factors. The studies included not only the effect on the prefrontal cortex but how the amygdala and hippocampus play a critical role in its function and development, so it's important to consider the different factors that were at play. Either way, the studies were still supported by appropriate data and in the end, show the great extent to which brain areas are affected by childhood physical abuse and trauma.

The research shows that when the amygdala and hippocampus have been damaged it then affects the developing prefrontal cortex to a great extent, completely altering its ability to function how it should. It highlights how they all work together and that the amygdala and hippocampus have a key role in developing the prefrontal cortex. Methodological considerations would have been that the studies had a lot of factors at play and how that could have hindered some of the results and reliability of the correlation in the studies. As far as those there weren't any other outstanding issues with the research. The research done for this section still effectively supports the thesis made.

Conclusion:

Throughout the research done in this paper, it's clear that childhood physical trauma greatly affects developing brain areas. The amygdala, hippocampus, and prefrontal cortex are the areas affected the most resulting in changes to size, function, and connectivity. As well as, mental health and cognitive issues occurring down the road. The findings show that the trauma puts the brain in a state of fear, releasing hormones that over time cause damage to those brain areas, altering the neural networks allowing brain areas to communicate and function. Through new research and advanced brain scans, it reveals how greatly the brain areas change in all aspects. Even though brain damage like this can't be repaired it raises the question if there can be anything done to help these brain areas adapt and function normally. It also begs the question of the effects of other types of trauma and if there's a correlation. The sources used were valuable in providing a deeper understanding of the effects of childhood trauma. However, some limitations were that many studies weren't able to use children in there MRI research for ethical reasons resulting in adults being used which meant more factors affecting the brain had to be accounted for. Overall, the paper clearly proves that childhood physical trauma leads to major effects in the amygdala, hippocampus, and prefrontal cortex.

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