Effects of PTSD on the Brain

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Over the past few years, there have been recent studies done on the effects of post-traumatic stress disorder and traumatic experiences on the human brain which emphasizes the importance of mental and physical health care. Some of the brain regions post-traumatic stress disorder can affect are areas of the frontal lobe, hippocampus, amygdala, hypothalamus, and even the brain stem. According to Niki et al. (2019), the frontal lobe function controlled and regulated cognitive tasks such as completing tasks without error and with attention. The hippocampus, an important part of the temporal lobe, controls learning and memory which Anand and Dhikav (2012) stated can play major roles in neurological and psychiatric disorders. The amygdala, however, controls emotional behavior (Anand & Dhikav, 2012) and when the amygdala is stimulated, Wright (2020) stated that it can cause intense emotion such as aggression or fear. The hypothalamus works with the pituitary gland to release necessary hormones for physical and sexual development as well as metabolic and immunity development (Shahid et al., 2022). According to Carlson and Burkitt (2017), the brain stem is made up of both the midbrain and hindbrain, both of which play important roles in survival regulation as well as sensory, visual, and auditory functions. The effects of post-traumatic stress disorder and traumatic experiences on the brain include changes in attention, learning and memory issues, emotional irregularity, sensory changes, and dysregulation of necessary functions such as cardiovascular function, skeletal muscle tone, and respiration.

The Frontal Lobe

As stated in the introduction, the frontal lobe controls completing tasks and the ability to follow directions. According to Niki et al. (2019), the frontal lobe is responsible for decision-making especially when performing tasks that require step-by-step instruction. The function also includes performing routine tasks which is controlled by the contention scheduling (CS) system while attention functions necessary for step-by-step tasks is regulated by the supervisory attentional system (SAS) (Niki et al., 2019). This affects functions such as cooking a recipe or taking a shower. Furthermore, the supervisory attentional system receives support from the prefrontal cortex while the contention scheduling system is connected to the basal ganglia and the motor cortex (Niki et al., 2019). Furthermore, the supervisory attentional system is supported by the prefrontal cortex which explains how it is important for functioning in time-sensitive tasks or for adapting to new environmental factors.

When considering events such as traumatic experiences or post-traumatic stress disorder, there has been evidence of negative effects on the frontal lobe. Certain types of brain damage can cause dysregulation regarding daily life routines through action reorganization syndrome (Niki et al., 2019). In a study by Gharehgazlou et al. (2021), they found clusters of heightened activity affecting the frontal lobe within the right hemisphere while clusters on the left hemisphere proved unchanged after isolating depression and anxiety. Additionally, a study by Fenster et al. (2018) found that there was decreased medial prefrontal cortex activity while also showing a decrease in the rostral anterior cingulate cortex and frontal cortex activity which affects attention, emotion, and arousal, especially when compared to those without a PTSD diagnosis. Evidence was also found that the size and activity of the ventromedial prefrontal cortex affects the ability to overcome fears through exposure therapy while also finding a connection between the left ventromedial prefrontal cortex and the amygdala in PTSD patients. Changes between the ventromedial prefrontal cortex and the amygdala can explain the sudden onset of anxiety usually associated with PTSD, which will be further explained later in the paper. Fenster et al. (2018) made a point to note that those who lack in prefrontal cortex functions may be at a heightened risk of developing PTSD after traumatic experiences; this could be due to not having adequate functioning in the prefrontal cortex. With this understanding, it can explain how important self-care tasks or mental health practices are in the event of a traumatic experience.

Alternatively, Pierce and Black (2021) brought the consideration of trauma survivors during infancy or childhood, when the development of the frontal lobe is still in stages of development, can hinder their ability to properly handle dangerous threats or situations when they become apparent. They went on to state that the superior frontal gyri, which is beneficial for self-awareness development can have positive impacts when development through therapy. There can be many separate effects on the frontal lobe through trauma and PTSD; however, many other areas of the brain are equally as affected.

The Hippocampus

A part of the temporal lobe, the hippocampus is also a part of the limbic lobe which can be affected most notably by Alzheimer's disease and epilepsy (Anand & Dhikav, 2012). The hippocampus affects memory, especially revisiting memories and using those memories to thrive in the future. Additionally, while the hippocampus primarily serves learning and cognition, it also serves spatial navigation which is the understanding of the cognitive processes and location awareness. Anand and Dhikav (2012) stated that the hippocampus works with the amygdala to also control emotional regulation while also communicating with the hypothalamus which controls the release of certain hormones such as cortisol. A normal hippocampus would show adequate usage of one's memories, comprehension of past events, and the ability to utilize those memories to make future decisions. Additionally, since it communicates with other areas of the brain, it is necessary that it functions properly, or it could negatively affect other limbic processes such as hormone release and emotional regulation.

Under traumatic stress and PTSD, observations through positron emission tomography (PET) and fMRI showed that trauma caused decreased hippocampal activity which proved how there is a failure to recall fear extinction from exposure therapy or other forms of fear conditioning (Abdallah et al., 2019; Fenster et al., 2018), as well as a reduction in volume in the hippocampus (Fenster et al., 2018; Sydnor et al., 2020; Yu et al., 2022). Additionally, some studies found that there was decreased activity in the ventral hippocampus which plays a role in regulation of emotional or anxious behavior changes (Fenster et al., 2018; Pierce & Black, 2021). Acquired from PTSD, the connectivity between the medial prefrontal cortex and the hippocampus can also decrease. Fenster et al. (2018) stated that it was still unclear about whether PTSD can lead to hippocampal atrophy, or the weakening of the hippocampus. However, noted by Abdallah et al. (2019), stress caused synaptic loss in the hippocampus as prolonged stress disrupts the signals needed to release cortisol as well as increased neuroinflammation. In this study, they were able to control the stressors, seeing hippocampal improvements between two to four weeks after withholding stressors. The study also noted that results were not consistent, but they were able to see that some cohorts has reduced hippocampal volume from long-term exposure to traumatic stress. A study from Pierce and Black (2021) noted that healthy activation of the hippocampus can be useful in rehabilitating from traumatic experiences; although, when it is overactive or even underactive, it can create a heightened fight-or-flight reaction, or decreased reaction, as the hippocampus is responsible for seeking out dangerous threats. It can be understood that trauma may have long-term effects on the hippocampal region; however, there are methods that may be able to improve its functioning.

The Amygdala

The amygdala is the crucial point of emotional regulation as it receives signals from the hippocampus as explained earlier. Additionally, Fenster et al. (2018) noted that the amygdala is also a key part of the limbic structure. When the amygdala is stimulated, it produces emotional reactions (Fenster et al., 2018; Wright, 2020). He also stated that in cases of epilepsy in the temporal lobe can stimulate the amygdala, and in extreme cases, will cause panic attacks. However, through experimental ablation in animal studies, lesions of the amygdala can cause tameness. The amygdala, like other parts mentioned, can have major implications regarding memory, fear processing/conditioning/extinction, and emotional regulation. The amygdala under normal pretenses would be able to emotionally regulate the individual and use information from other brain regions to function more adequately.

A study by Fenster et al. (2018) found that increased activity in the amygdala was apparent during symptom provocation studies with individuals who struggle from PTSD. The connections of the amygdala and other sections of the brain can be inhibited due to PTSD considering memory related to trauma and what the individual may feel at the time of reactivating those memories. The study also brought forth evidence that changes to the connection between the ventromedial prefrontal cortex and the amygdala were present in individuals with PTSD; however, the vmPFC-inhibition had been proven useful in fear extinction. Evidence showed that individuals with PTSD would show avoidance behaviors after receiving a negative stimulus, furthering proving that the avoidance can cause fear extinction inhibition. Essentially meaning that fears will stay fear if consistently avoided. Additionally, with increased amygdala activity, it explains the general presence of fear since the amygdala stimulates emotional regulation and the fear response (Fenster et al., 2018; Yu et al., 2022). Other studies found evidence which proved that different methods of therapy can decrease the stimulation of the amygdala which controls the fear response (Pierce & Black, 2021; Sydnor et al., 2020; Yu et al., 2022). In the study by Yu et al. (2022), they found that the hippocampus receives information from the amygdala in order to use their memory and learn more efficiently and since the hippocampus and amygdala are associated with PTSD symptoms (Sydnor et al., 2020), if this connection is inhibited in any way, it affects the learning processes of the individual. The amygdala can have effects on many other regions, especially since different regions work together to produce conducive results for survival and livability.

The Hypothalamus

The hypothalamus, which works in conjunction with the pituitary gland, is responsible for releasing hormones such as gonadotropin and growth hormones (Shahid et al., 2022). The hypothalamus releases thyroid hormones, growth hormones associated with puberty and reproduction, as well as other hormones used to inhibit other released hormones such as dopamine or somatostatin. When operating at normal capacity, depending on the phase of life, a female could be fertile, their weight changes would be normal, and moods would be stable. However, any impairment or damage could cause appetite changes, temperature tolerance, or hormone fluctuations. An important note by Shahid et al. (2022) mentioned that these issues could be caused by “intracranial masses, vascular abnormalities, ischemia, and also by certain medications such as antipsychotics” (para. 10). In other words, tumors, strokes, and medications can cause damage to the hypothalamus.

In the study by Pierce and Black (2021), increasing stressors during infancy can induce hyperarousal in the hypothalamic functions, which evidence has shown can lead to PTSD in adolescence and adulthood. Furthermore, Yu et al. (2022) described the same hyperarousal as problematic while finding that they were able to improve abnormal behavior through decreasing glucocorticoid receptors within the hypothalamus. While the amount of research regarding the effects on the hypothalamus are minute compared to the other regions, it provides a new path to consider when dealing with the effects of PTSD.

Conclusion

Research on post-traumatic stress disorder over recent years has provided great insight on the physical effects on the human brain as the brain holds necessary functions to survive. The likelihood of traumatic experiences having long-term effects is unknown; however, the possibility is high especially with the latest evidence proving the stress that current trauma and/or PTSD can have on the brain which could affect other areas of the human body. It is known that PTSD can cause behavioral changes, but it can also affect hormonal changes, learning abilities, survivability. It is important to continue the research on this topic regarding long-term disabilities and mental illnesses that can affect the daily life of an individual.

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