

The background of the entire page is an abstract, high-contrast artwork. It features thick, swirling lines in vibrant red and bright yellow, set against a deep black background. The patterns are reminiscent of a tunnel or a complex, organic structure, with some areas showing a grid-like texture. The overall effect is one of intense energy and depth.

PTSD: The Way In & The Way Out

By Carolyn Herbosa

Have you ever been tempted to buy adaptogen-spiked sparkling sodas? Gummies that promise to make period pain go away? Even supposedly-aphrodisiac candles? I have (and honestly, the period gummies are life-changing)! We live in an age of product saturation of every kind. You can have your pick of items that promise to heal you in every imaginable way, such as those made famous courtesy of Gwyneth Paltrow and her mega-brand Goop. Snake oil salesmen have been around since the dawn of capitalism, and today they take a new yoga-doing, coffee-enema getting, incense-burning, form. The monetization of the health industry and health products means we all are constantly toggling between roles as consumers and patients, and we're treated as both by companies that simultaneously promise to help us and sell us something.

On May 22, 2017, one of the world's busiest indoor stadiums, Manchester Arena, was bombed [1],[2]. The Manchester Arena has a capacity of 21,000 people and is known for hosting numerous sporting and music events featuring world renowned celebrities, including Ariana Grande [1]. Unfortunately, Grande and all of her fans were unaware that they had signed up for such a catastrophic event. This home-made bomb was detonated by a suicide bomber following Grande's concert leaving 22 young adults and children dead, 1,017 people injured, and thousands with life-long trauma, including pop star: Ariana Grande [2].

Nearly two years following the event, Grande shared with the public MRI scans of her brain through the popular social media app, Instagram [3]. The Instagram Story compares im-

ages of her brain following the bombing to you would see in a healthy MRI brain scan (Figure 1). Grande's brain scans showed drastic differences from a healthy brain, but similar to those affected by post-traumatic stress disorder (PTSD). While Grande hasn't expressed further emotions about her experience, she stated that she "doesn't know how to talk about it and not cry" [3]. Grande's emotions are intense and real, yet she captioned the story, "hilarious and terrifying". I would say this is more terrifying than hilarious, Ariana is right about one thing, this is not a joke. PTSD is not a joke.

Unfortunately, there are millions of people worldwide who are subject to PTSD, but do not have the access to a personal brain scan. Approximately 3.9% of the world's population has been diagnosed with PTSD [4]. These victims suffer from the drastic symptoms PTSD brings. The question becomes: have the brains of these

victims changed forever?

What is PTSD?

Many people have heard of PTSD in terms of war and combat veterans having flashbacks; however, PTSD is not that simple. PTSD is a mental disorder that develops following a traumatic, dangerous, or terrifying event. While most people have gone through some sort of trauma, not everyone develops PTSD. Approximately 7-30% of people who have experienced trauma have developed PTSD at some point in their life [5].

Although PTSD and the symptoms are most commonly thought of with war veterans, war is not the only cause of PTSD. Rape victims alone make up nearly half of the PTSD population (Figure 2). The combination of rape and other forms of sexual assault make up nearly 75% of PTSD patients. Anyone who goes through a traumatic event which involves actual or threatened death, serious injury, or sexual violation can develop PTSD. Following rape, physical assault or severe bleeding make up the next largest cause of PTSD patients with 31.9% [4]. Other causes of PTSD involve serious injury caused by an accident, stabbing or shooting incidents, unexpected or sudden death of a loved one, life-threatening illness of a child, seeing someone being killed or seriously injured, and natural disasters [4]. Regardless of the cause of PTSD, the symptoms can vary greatly, not all wounds are visible. Symptoms of PTSD can start within one month to years following the traumatic event. These symptoms can range from mild to severe and can last for months or a lifetime, interfering with day-to-day functioning. PTSD is categorized into 4 symptom groups: intrusive memories, avoidance, negative chang-



Figure 1: Ariana Grande's Instagram Story sharing her MRI brain scan. Under Fair Use for non-commercial educational purposes.

es in thinking and mood, and changes in physical and emotional reactions though symptoms can vary over time and from person to person [6]. Thinking back to the fans of the Ariana Grande concert, some may wake up with nightmares and are easily startled, while others avoid crowded places and experience depression.

The diagnosis of PTSD is evaluated through a physical exam and psychological evaluation completed by a psychologist or doctor. This criteria follows the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) provided by the American Psychiatric Association. Following direct exposure to an event that involved actual or possible threat of death, violence, or serious injury, a person will be diagnosed with PTSD if they experience one or more of the symptoms in each category of symptoms [7].

Stress on the Body

Neuroendocrinology is a division of neuroscience and is primarily focused on the study of hormone regulation via the brain. Think about whenever you get hungry - your stomach may start growling at you; then you start to crave different foods. Whenever the stomach is empty, it releases a hormone called ghrelin: the hormone that makes you feel hungry. Ghrelin then finds its way up to the brain, and the brain tells you that you're hungry. The process of feeling stress is not so different. Our response to stress is due to the hormones that are produced from our brain and other organs; like our kidneys.

Whenever someone is stressed, the hypothalamic-pituitary adrenal axis (HPA) is activated. The HPA axis includes (as the name suggests): hypothalamus, pi-

uitary glands, and adrenal glands. It serves as a connection from the brain - starting at the hypothalamus - to the body - ending at the adrenal glands which are above the kidneys [8],[9].

The hypothalamus is mainly known for its role in homeostasis, which is the body's natural state of balance. While this may not seem important to PTSD, the hypothalamus is also responsible for communicating with the amygdala [8-11]. The amygdala is the part of the brain responsible for feeling fear. Once the amygdala activates the hypothalamus, there is an increase of two commonly known hormones: cortisol and adrenaline (Figure 4). Whenever someone is stressed, the hypothalamus releases a series of hormones that go all the way from the brain, hypothalamus and pituitary gland, to the kidney where the adrenal glands are located. These hormones stop at each of the parts of the HPA axis to produce other hormones, which are eventually received by the adrenal glands [8],[9]. The main hormone that is produced by the HPA axis is cortisol. As mentioned before, cortisol is the main stress hormone in the body. Cortisol is responsible for the feelings of stress, such as an increased heart rate [8],[9].

Typically, when enough cortisol is produced and your brain and body recognize that there is no more threat or reason to be stressed, the excess cortisol tells the brain to stop production of this hormone. However, victims of PTSD have a dysregulated HPA axis [8],[9]. This means that instead of excess cortisol telling the brain to stop producing more cortisol, the signal is never received and the HPA axis works in overdrive. People with PTSD have hyperactive stress responses to simple things that may or may not correlate to their trauma. This

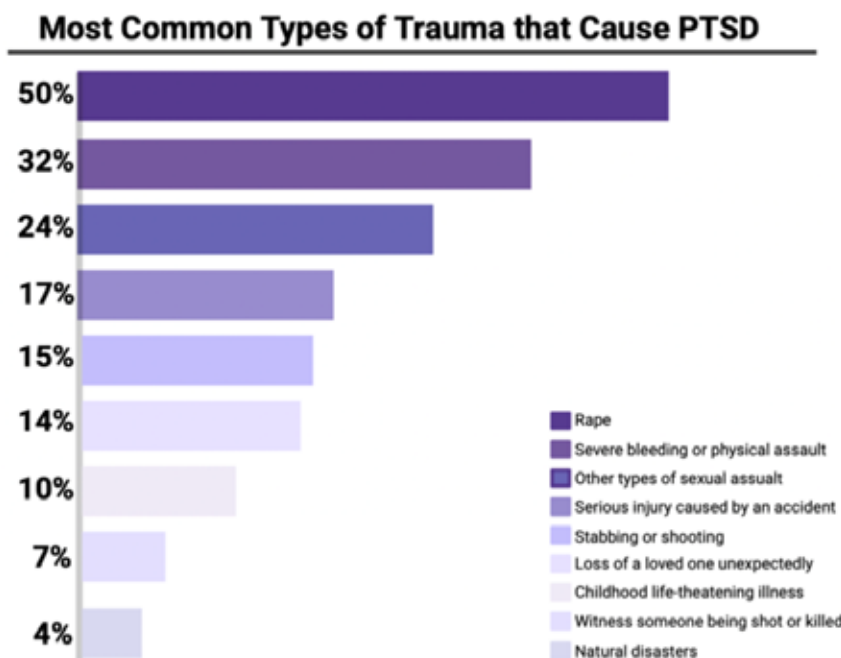


Figure 2: Graph showing the most common causes of PTSD. Original image by Carolyn Herbosa. Adapted from Nina Julia. Created in BioRender.

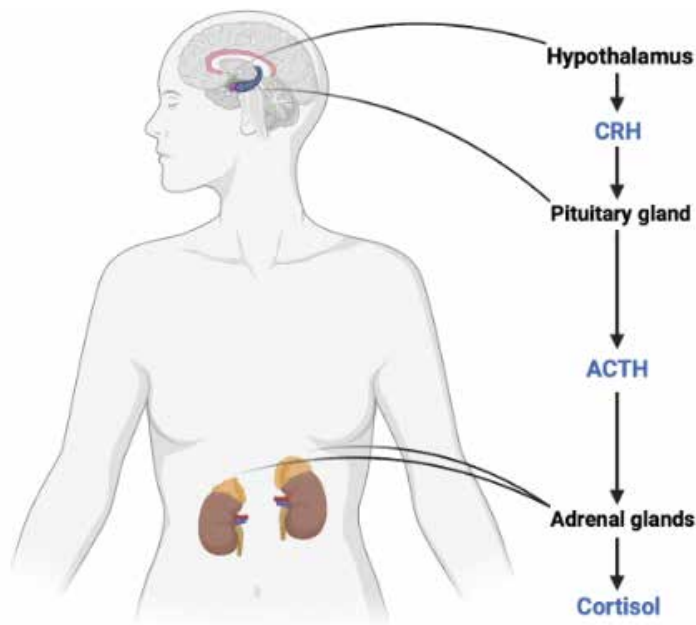


Figure 3: The HPA axis connects from the hypothalamus to the anterior pituitary in the brain to the adrenal glands above the kidneys. Original image by Carolyn Herbosa. Adapted from Ben Greenfield Life. Created in BioRender.

dysregulation contributes to many symptoms of PTSD [8],[9].

Similarly, adrenaline is produced in response to activation of the amygdala. Once the amygdala has been activated, it communicates with the hypothalamus to eventually produce adrenaline in a similar fashion. You may have heard of adrenaline in relation to running or taking a risk. In terms of physical exercise, adrenaline increases your heart rate to get more oxygen to your muscles. This is similar to the adrenaline production in response to stress. Adrenaline activates the “fight-or-flight” response to help our bodies react more quickly [11]. Typically, adrenaline causes the effects of feeling nervous such as increased heart rate and sweaty palms. However, in victims of PTSD, adrenaline is produced in higher amounts than normal. Thus, people with PTSD may have numbed emotions and hyperarousal [10],[11].

The crucial role the HPA axis plays in the production of PTSD has drawn the attention of researchers. Two drugs that are

used to regulate the HPA axis are Antalarmin and

Dexamethasone [12],[13]. Antalarmin acts to stop the production of the first hormone of the HPA axis, corticotropin releasing hormone [13]. This drug works to prevent the overproduction of hormones, so the stress response is stopped early on. Dexamethasone blocks cortisol receptors in the brain from receiving cortisol so that we don’t feel the effects of stress [12]. While both Antalarmin and Dexamethasone are still being researched, they offer promising results as a possible treatment for PTSD [12],[13].

Stress on the Brain

Our brains dictate who we are, serving many crucial functions, but brains are delicate. Physical trauma, (like falling out of a chair), can cause damage to your brain; emotional experiences, especially strong ones, cause brains

to undergo changes. That is why experiencing something as drastic as a bomb explosion can change someone’s brain and produce PTSD.

To better understand the causes of PTSD symptoms, it is important to understand root causes of PTSD. In the millennia past, humans evolved to survive attacks from saber tooth tigers causing the psychological sequelae of stress. While there are no saber tooth tigers currently walking through the streets, the neurological changes that cause severe stress and anxiety have stuck around.

The natural alarm system becomes easily triggered and overly sensitive for those with PTSD. In the brain, the main three parts that have been associated with PTSD are the hippocampus, amygdala, and prefrontal cortex [10],[11].

The hippocampus is the memory center of the brain [10],[11],[14]. This part of the brain allows us to remember and recall events, objects, people, etc. Many people with PTSD will have flashbacks or nightmares as the hippocampus focuses on one memory as it tries to understand what is happening. The fans at the concert may have nightmares of the bomb explosion or flashbacks of seeing all those that were injured or killed. On the other hand, the memory center may shut down as it tries to black out the memory for the person’s safety. In either case, the hippocampus isn’t as active as before. Therefore, there is an overproduction of stress hormones, causing the neurons to die off and result in a shrunken hippocampus [10],[11],[14]. Damage to this part of the brain caused by PTSD contributes to the symptoms of unwanted feelings, flashbacks, and paranoia.

The amygdala is the body’s natural alarm system and is often

associated with anxiety. In simple terms, the amygdala is what makes people feel fear [10],[11],[14]. The role of the amygdala is to keep a person safe, however, those with PTSD have an overactive amygdala response. This part of the brain is responsible for the symptoms of avoidance and changes in physical and emotional responses, such as being startled by a leaf falling [10],[11],[14].

Commonly known, is the association of the prefrontal cortex with personality and decision making. The prefrontal cortex allows us to think through consequences and manage emotional reactions to allow us to realize something isn't as fearful as the initial response [10],[11],[14]. One of the concertgoers may have previously enjoyed loud music, being in crowds, partying, but after the bombing, the fan could easily become fearful of a crowded room or loud noises to the point where they cannot be there physically or mentally anymore. This is because the prefrontal cortex has become damaged and is now less active [10],[11],[14]. They won't have the insight to realize that going to a popular mall will not result in another bombing. There are more

specific parts of the prefrontal cortex, such as the medial and orbital prefrontal cortex, that contribute to specific symptoms. These specific parts combine to contribute to the decrease in decision making and awareness.

While the cingulate cortex is not as widely associated with PTSD, it may have a contributing factor. The cingulate cortex is also involved in emotions and behavior recognition similarly to the prefrontal cortex [11],[14]. In the same manner, there are specific parts of the cingulate cortex that contribute to symptoms of PTSD. The prefrontal cortex and the anterior of the cingulate cortex contribute to attention, habit formation, and emotional expression [11],[14]. This means that someone from the concert could begin to have changes in their emotional states such as depressive episodes. These brain regions have been found to be smaller than a healthy adult which contributes to the symptoms [11],[14].

So that's the long story, in an attempt to convince you that the brain does change. But even though Ariana Grande's brain scans look scary and intimidating, just as the brain changed in

response to trauma, it can revert back to the healthy brain.

It'll Get Better

While PTSD results from brain and neuroendocrine dysregulation, there is a large amount of current research on PTSD. Recently neuroscientists have begun to study psychotherapy and have found that the brain can be rebuilt [15]. Therapy provides an environment that allows brain cells to develop. Low amounts of stress actually causes the brain to shift to focus on learning. During therapy, a therapist may help someone with PTSD recall the traumatic event in a controlled environment allowing low amounts of stress to be activated [15]. Then, the therapist will help the patient rework the trauma in an effort to learn how to cope with the stress in a manner that actually causes more brain cells to grow and reconnect. There are many different techniques that a therapist might use to help someone, but overall, the environment of therapy, the empathy of the therapist, and their many techniques provides an enriched environment for the brain to begin to rebuild itself [15].

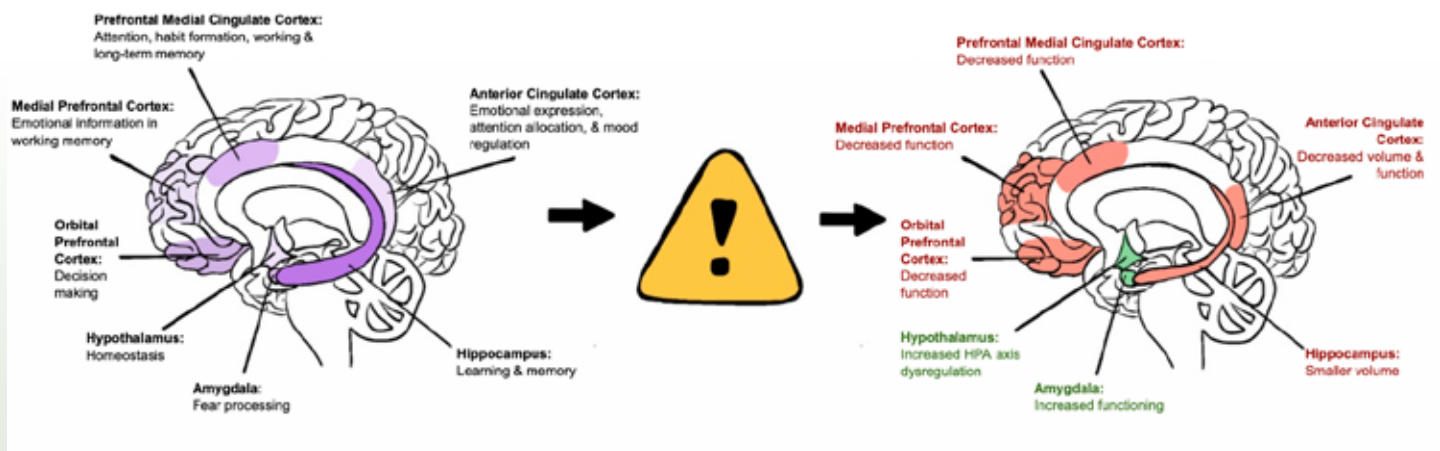


Figure 4: The increase and decrease of brain region function and volume caused by PTSD produces symptoms of intrusive memories, avoidance, negative changes in thinking and mood, and changes in physical and emotional reactions rather than their typical roles. Image created by Carolyn Herbosa. Created on Procreate adapted from Bermner, 2006.



The main form of treatment is psychotherapy which can be accomplished by working with a therapist [16]. Psychotherapy focuses on helping the patient work through intrusive thoughts, memories, and other symptoms of PTSD by providing an environment that allows neurons to reconnect and the person to regain control of their life. Therapists use different techniques such as cognitive therapy, exposure therapy, and eye movement desensitization and reprocessing to help patients [16].

Cognitive therapy helps a patient to recognize unproductive thinking patterns, and to focus on their ability to communicate. Through this, the patient regains control and function of their medial prefrontal cortex, hippocampus, and cingulate cortex [16]. Exposure therapy is a behavioral therapy that helps patients face situations and memories that trigger PTSD symptoms [16]. The exposure therapy places a patient physically or mentally in a symptom triggering environment. However, before the PTSD takes control of the patient, a therapist

will help the patient work through the exposure and response. Exposure therapy will teach the patient how to use their orbital frontal and medial prefrontal cortex while also controlling their cingulate cortex and hippocampus [16]. Another way to look at it, is the patient should be able to sense a trigger, consciously recognize there is no real threat, and thus prevent the HPA axis from initiating a stress response [16]. Finally, a therapist may use eye movement desensitization and reprocessing. The goal of this therapy is to use the orbital frontal and medial prefrontal cortex to again prevent the onset of symptoms [16]. This is a more intense form of exposure therapy where the psychologist leads the patient through guided eye movements throughout exposure therapy to change how they react. On top of this, a therapist will help manage stress and provide the patient with coping mechanisms in order to deal with other stressful situations of life.

Similar to many other mental health struggles, someone with PTSD may be prescribed medi-

cation. There are a few types of medication a psychiatrist or other doctors may prescribe. The first is antidepressants [16]. These medications help reduce symptoms of depression and anxiety and improve sleep and concentration. One example of an antidepressant is an SSRI, or selective serotonin reuptake inhibitor (e.g., Prozac). SSRIs help someone with depression, anxiety or PTSD by blocking the breakdown of serotonin so they will feel the positive, happy effects of serotonin more than they previously were. For those with severe anxiety a doctor may prescribe anti-anxiety medication [15]. These medications will help relieve severe anxiety, however, they are only used for a short period of time. Anti-anxiety medications act on the amygdala, hippocampus, and hypothalamus to decrease or prevent the formation of the stress response. Finally, for those who experience high symptoms of nightmares and flashbacks, a patient may be prescribed Prazosin. Prazosin is still being studied but has been shown to reduce or even suppress nightmares in people with PTSD [16]. Given that Prozac reduces nightmares, we know that it works on the hippocampus and amygdala.

Regardless of whether a patient chooses psychotherapy or medications, the treatments work on the same areas of the brain: amygdala, hippocampus, hypothalamus, medial frontal and orbital frontal cortex, and cingulate cortex. While the treatments target these brain regions, every person is unique. Any one form of therapy is no better than another form of therapy. It is important to test out various options and find what works for you. Before searching for medication or attempting psychotherapy on yourself, you should work with a doctor to find the best treatment for you.

Risk vs. Resilience

While everyone experiences trauma in their life and anyone can develop PTSD at any age, not everyone does. As discussed earlier, 7-30% of people develop PTSD; the wide gap is due to inconsistencies of who gets PTSD, the symptoms, and when it occurs [5]. The scientific underpinnings of why one develops PTSD and other does not even though they experienced the same trauma, is not quite understood. However, there are some risks and resilience factors that have been thought of as reasons.

One of the biggest factor that contributes to the development of PTSD is the severity of the trauma [17],[18]. This is why whenever you hear about PTSD it is correlated with combat, rape or bomb explosions. Another big factor is whether or not someone has childhood trauma. Experiencing child abuse prior to a trauma-

matic event as an adult, leads to an increased risk of developing PTSD [17],[18]. Similarly, the age of someone may contribute to PTSD. Experiencing trauma at a young age during neurodevelopment, puts you at higher risk for developing PTSD at the time or later in life as an adult [17],[18]. Furthermore, there is some research that has shown there is a correlation to genetics and heritability to the development of PTSD. While those are the biggest risk factor, there are other risks such as working a high-risk job, being taken into foster care, having no or little social support, and having a personal or family history of mental health or substance use issues [17].

While there is a wide range of risk factors, there is also a wide range of resilience factors. The biggest factor is getting social support from loved ones [17], [18]. Having people that you care about and people that love you to support you through troubling times will help prevent PTSD development. Another factor is having ways to deal with stress such as art, music, reading or anything

that will help you cope will help you work through trauma before it becomes PTSD [17],[18]. Seeking support from a professional will help someone work through their trauma and find helpful ways to deal with negative thoughts. Other resilience factors that contribute to the prevention of PTSD development include: learning to manage emotions and avoiding unhelpful coping mechanisms[17].

Even if you have already been affected by PTSD, there are ways to build resilience in response to the trauma. The steps of overcoming PTSD are acceptance, building connections, perspective, focusing on relationships, self-care, goal setting, mindfulness, and professional help [17]. Although PTSD may be an intimidating beast, most people who have developed PTSD have been able to overcome it and continue their normal lives—even Ariana Grande.



PTSD Foundation of America: (877)717-PTSD (7873)
National Suicide Prevention Line: 1-800-273-TALK
Substance Abuse and Mental Health Services Administration: (800)662-4357
Text HOME to 741741 for the Crisis Text Line

References

1. . "Manchester Arena," Wikipedia, 21-Oct-2022. [Online]. Available: https://en.wikipedia.org/wiki/Manchester_Arena. [Accessed: 16-Nov-2022].
2. "Manchester Arena bombing," Wikipedia, 14-Nov-2022. [Online]. Available: https://en.wikipedia.org/wiki/Manchester_Arena_bombing. [Accessed: 16-Nov-2022].
3. G. Sorto, "Ariana Grande Shares Brain Scan and opens up about PTSD," CNN, 13-Apr-2019. [Online]. Available: <https://www.cnn.com/2019/04/12/entertainment/ariana-grande-ptsd-brain-scan-instagram-tr nd>. [Accessed: 16-Nov-2022].
4. N. Julia, "Post-traumatic stress disorder (PTSD) statistics: 2022 update," CFAH, 29-Oct-2022. [Online]. Available: <https://cfah.org/ptsd-statistics/>. [Accessed: 16-Nov-2022].
5. C. M. Sheerin, M. J. Lind, K. E. Bountress, N. R. Nugent, and A. B. Amstadter, "The genetics and epigenetics of PTSD: Overview, recent advances, and Future Directions," *Current Opinion in Psychology*, 28-Sep-2016. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2352250X16301178?via%3Dihub>. [Accessed: 16-Nov-2022].
6. Mayo Clinic Staff, "Post-traumatic stress disorder (PTSD)," Mayo Clinic, 06-Jul-2018. [Online]. Available: <https://www.mayoclinic.org/diseases-conditions/post-traumatic-stress-disorder/symptoms-causes/syc-20355967>. [Accessed: 16-Nov-2022].
7. "Trauma-Informed Care in Behavioral Health Services - NCBI bookshelf," National Library of Medicine: National Center for Biotechnology Information, 2013. [Online]. Available: <https://www.ncbi.nlm.nih.gov/books/NBK207191/>. [Accessed: 16-Nov-2022]. pp. 271-272
8. B. W. Dunlop and A. Wong, "The hypothalamic-pituitary-adrenal axis in PTSD: Pathophysiology and treatment interventions," *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 17-Oct-2018. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0278584618306882?via%3Dihub#section-cited-by>. [Accessed: 16-Nov-2022].
9. S. M. Smith and W. W. Vale, "The role of the hypothalamic-pituitary-adrenal axis in neuroendocrine responses to stress," *Dialogues in clinical neuroscience*, 08-Dec-2006. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3181830/>. [Accessed: 16-Nov-2022].
10. "How PTSD affects the brain," BrainLine, 07-May-2019. [Online]. Available: <https://www.brainline.org/article/how-ptsd-affects-brain>. [Accessed: 16-Nov-2022].
11. J. D. Bremner, "Traumatic stress: Effects on the brain," *Dialogues in clinical neuroscience*, 2006. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3181836/>. [Accessed: 16-Nov-2022].
12. Aru, M., Alev, K., Pehme, A., Purge, P., Önnik, L., Ellam, A., Kaasik, P., & Seene, T. (2019, November). Changes in body composition of Old rats at different time points after Dexamethasone Administration. *Current aging science*. Retrieved September 29, 2022, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6635420/>
13. Zorrilla EP;Valdez GR;Nozulak J;Koob GF;Markou A; "" Brain research. [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/12376179/>. [Accessed: 17-Nov-2022].
14. D. J. Nutt and A. L. Malizia, "Structural and functional brain changes in posttraumatic stress disorder," *Psychiatrist.com*, 04-Feb-2021. [Online]. Available: <https://www.psychiatrist.com/jcp/trauma/ptsd/structural-functional-brain-changes-posttraumatic/>. [Accessed: 16-Nov-2022].
15. Malhotra, S., & Sahoo, S. (2017). *Rebuilding the brain with psychotherapy*. Indian journal of psychiatry. Retrieved December 13, 2022, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5806319/>
16. Mayo Clinic Staff, "Post-traumatic stress disorder (PTSD)," Mayo Clinic, 06-Jul-2018. [Online]. Available: <https://www.mayoclinic.org/diseases-conditions/post-traumatic-stress-disorder/diagnosis-treatment/drc-20355973>. [Accessed: 17-Nov-2022].
17. K.-M. Hall, "Why do some people get PTSD and other people don't?," GoodRx, 16-Aug-2021. [Online]. Available: <https://www.goodrx.com/conditions/ptsd/why-do-some-people-get-ptsd-not-others>. [Accessed: 16-Nov-2022].
18. Wpengine. (2022, August 26). Why do some people get PTSD while others don't? Recovery Ways. Retrieved December 13, 2022, from <https://www.recoveryways.com/rehab-blog/why-do-some-people-get-ptsd-while-others-dont/>