Behind the Scenes of Fear

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Abstract

Fear is one of the six fundamental emotions that shape humans today, and is key in learning about the brain. Best known for fear and anxiety regulation, the amygdala is the portion of the brain that processes emotions and is the most important region in fear control. Neurotransmitters such as serotonin and norepinephrine aid in the modulation of this emotion throughout the brain, as their distinct receptors and subtypes trigger specific responses that result in the expression of fear. Related to many neurological and psychiatric conditions, fear is the underlying emotion that is involved in certain disorders, and many treatment options and cures are currently being studied. Genetic factors of fear are under research to assist in medical treatment of conditions as well as helping in further understanding the transmission of fear within families. Being present as parts of individuals' daily emotions as well as research and healthcare, fear and its regulation is an essential part of humans and the brain.

Neurotransmitter Systems Involved

Neurotransmitters are chemical messengers that relay signals from neurons to target cells throughout the body, and are known to control and regulate emotions. The main neurotransmitters associated with fear include glutamate, serotonin, norepinephrine, and GABA (gamma-aminobutyric acid). Glutamate is the most common excitatory neurotransmitter present in the brain and promotes learning through enhancing synaptic connections in the brain, especially in the region called the amygdala which contributes to processing fear. Furthermore, glutamate strengthens neural connections that form memories associated with fear, enhancing its role in fear learning. Managing mood, anxiety, pain and more, serotonin is an inhibitory neurotransmitter that is associated with disorders such as anxiety and depression as a result of its imbalances in the body. Anxiety is a condition that evolves partially because of the excessive amount of fear regulated within the body as a result of increased serotonin levels and low levels of neurotransmitters associated with positive feelings, such as dopamine. Norepinephrine, also known as noradrenaline, is a neurotransmitter and a hormone expressed in the "fight or flight" response that is controlled in the amygdala when presented to a threat. During this response, norepinephrine can elevate glutamate levels, which creates neuronal connections that form memories related to the event, impacting the fears or phobias an individual may have. Opposing glutamate, GABA is the primary inhibitory neurotransmitter in the brain which acts as a "brake" by inhibiting fear-related neural connections in the amygdala, and produces a calming effect through controlling nerve cells during a state of anxiety or fear.

Receptors, Subtypes and their Anatomy

Neurotransmitters possess specialized receptors to bind to that come in many subtypes, resulting in varying effects on the body. The receptors have unique subtypes that work together to help exhibit behavioral and cognitive processes such as fear and anxiety regulation. The most common neurotransmitter receptors and subtypes include dopamine with D1 and D2 receptors, serotonin using 5-HT1A and 5-HT2A subtypes, GABAA and GABAB receptors, and NMDA

receptors for glutamate. Serotonin's 5-HT1A and 5-HT2A either inhibit or promote anxiety and fear in the mind. 5-HT1A receptors are known to be anxiolytic, meaning they reduce fear learning whereas 5-HT2A receptors are anxiogenic, translating to enhanced neural connections that increase fear learning. These receptors are distributed across the brain, and are also located in the amygdala - which is the region of the brain that mediates fear - the hippocampus, which stores memory and is crucial for learning - and the prefrontal cortex which regulates emotions. All of these are essential regions for fear processing. Similar to serotonin receptors, other neurotransmitters possess multiple receptors that have different effects on the body related to fear learning such as inhibiting or increasing memory formation and strengthening or weakening neural connections while some are inhibitory or excitatory. Other neurotransmitters and receptors are critical for fear learning and regulation, as each individual receptor and subtype have unique effects that work together to create the fear system in the body.

Genetic and Environmental Factors

Fear is heavily impacted by genetic factors, including phobias that are diagnosed within families. Genetics influence fear and anxiety disorders with rates from 35% to 45%, resulting in the many phobias such as hemophobia and arachnophobia running in families. The formation of certain regions of the brain that are correlated with fear like the striatum and thalamus impact the development and extent of fears' presentation, from mild to as extreme as phobias. Environmental factors, for example trauma and stressful experiences, further elevate the expression of fear, especially during childhood as the brain is maturing. These experiences are likely to create strong memories associated with trauma, enhancing the emergence of the fear from childhood through adulthood. Moreover, observing the differences between sexes, including hormones and brain structure and function, certain phobias and conditions are more likely to be inherited by women rather than men. Studies show that cortisol - a hormone coupled with a stress response - is found in higher levels in women in response to stress compared to men because of hormonal fluctuations through pregnancy, menopause and puberty. Through the greater hormonal changes in women, anxiety development may be more prominent for them. Genetic factors also influence the transmission of phobias and conditions between parents and children, and are being studied by researchers.

Neurological and Psychiatric Conditions Associated

Extreme expressions of fear can result in phobias and certain neurological/psychiatric conditions such as Anxiety and Post Traumatic Stress Disorder (PTSD). Anxiety by itself is not a disorder because in moderation it is able to encourage individuals to be cautious and safe, but it can evolve over time as an excessive amount is not healthy for an individual. As a branch of fear, anxiety occurs when one is worried about a threat or event that may never occur. It can become a diagnosable condition when it is overexpressed and interferes with everyday lives such as having continuous negative thoughts, which can detrimentally affect individuals socially and emotionally. If not dealt with, those diagnosed with anxiety disorders may develop clinical depression and can begin to socially isolate themselves from family and friends, worsening their emotional health. Mentally, sleep disturbances, constant fear and worry, restlessness, trouble making decisions and concentrating are all traits of anxiety whereas some physical traits of anxiety include heart palpitations, shortness of breath and nausea. In addition, PTSD is a

neuropsychiatric disorder in which those diagnosed re-experience trauma from the past, through intrusive thoughts, nightmares, and avoiding the topic of the traumatic experience. Similar to anxiety, when diagnosed with PTSD, negative emotions become more prominent with feelings of worthlessness arising, increasing distance between close relationships such as friends and family. It is common for those battling PTSD to be dealing with other conditions such as depression and anxiety, which are the most frequent. These additional conditions are normally developed as an immediate result of a traumatic experience or as an outcome of being diagnosed with PTSD. General symptoms of PTSD include sleeping difficulties, hypervigilance, detached from reality, and intense flashbacks, all because of the incident from the past.

Cures and Treatment Methods

Although there are no cures for PTSD or anxiety, both conditions are treatable and can be managed, significantly reducing their effects and symptoms and allowing people to continue living their normal lives. Anxiety can be treated through forms of therapy, anxiety medication or both. Different forms of therapy are available such as psychotherapy with cognitive behavioral therapy (CBT) and exposure therapy which are branches of psychotherapy. Psychotherapy, or “talk therapy” is known to be the most helpful as it involves having a conversation specialized to the experiences of the patients. CBT is a form of psychotherapy in which the patient is taught how to behave, react and think differently in situations to help reduce anxiety at any given time, whereas exposure therapy includes being exposed to the origin of the stress to be able to confront and react to it in a better manner. The most commonly used medications to reduce anxiety are antidepressants and benzodiazepines. SSRIs (Selective Serotonin Reuptake Inhibitors) and SNRIs (Serotonin and Norepinephrine Reuptake Inhibitors) are the most popular antidepressants, which are used to boost the release of certain neurotransmitters such as serotonin and norepinephrine. Through the increase of neurotransmitters which regulate positive emotions and mood, antidepressants are able to help cease symptoms relating to fear, worry, and panic. Benzodiazepines slow down brain activity, acting as a sedative and displaying a calming effect because it intensifies the effects of GABA, which is a chemical in the brain that helps reduce nerves and promotes calmness. Benzodiazepines need to be prescribed by an experienced professional since it can become addictive and has many resulting detrimental side effects, making antidepressants more widely used. Like anxiety, those suffering from PTSD can be treated through the talk therapies listed above, more specifically focusing on trauma-related topics to enhance resistance towards PTSD symptoms. Medications like antidepressants are also used. Examples include paroxetine, sertraline, and venlafaxine, but effectiveness varies on the dosage. Forms of talk-therapy are generally because medication can only cure symptoms while the proper dosage is being taken. Once patients stop taking medication, symptoms may continue to arise. For both conditions, it is important for those diagnosed to be aware of their emotions and learn how to manage them with the help and support of counselors and families to help reduce their symptoms and get the best treatment possible.

Conclusion

Fear is a complex emotion that is associated with many medical conditions and is continuing to be studied for medical and research purposes. Its’ regulatory system involves numerous hormones, neurotransmitters, receptors and their subtypes to work together and

process and exhibit fear in the body. With genetics playing a role in the expression of fear, studies are continuing to be conducted to explore the inheritance of fear and conditions related to help increase cure and treatment options that are safe. Overall, fear is a versatile emotion that is expressed in so many ways in individuals' daily lives, and is continuing to be explored in various fields.

References

1. *Understanding fear, anxiety, and phobias | mclean hospital*. Mass General Brigham McLean. (2025). https://www.mcleanhospital.org/essential/fear-phobias
2. Department of Health & Human Services. (1999, May 18). *Anxiety disorders*. Better Health Channel. https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/anxiety-disorders
3. Department of Health & Human Services. (2000, March 15). *Post-traumatic stress disorder (PTSD)*. Better Health Channel. https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/post-traumatic-stress-disorder-ptsd
4. World Health Organization. (2023, September 27). *Anxiety disorders*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/anxiety-disorders
5. *Anxiety disorders symptoms & treatment: Aurora Health Care*. Anxiety Disorders Symptoms & Treatment | Aurora Health Care. (n.d.). https://www.aurorahealthcare.org/services/behavioral-health-addiction/anxiety-disorders#
6. Cleveland Clinic. “Anxiety Disorders.” *Cleveland Clinic*, 3 July 2024, my.clevelandclinic.org/health/diseases/9536-anxiety-disorders.
7. ---. “BENZODIAZEPINES (BENZOS).” *Cleveland Clinic*, 1 Mar. 2023, my.clevelandclinic.org/health/treatments/24570-benzodiazepines-benzos.
8. “PTSD Treatment Basics - PTSD: National Center for PTSD.” *Va.gov*, 2014, www.ptsd.va.gov/understand_tx/tx_basics.asp. Accessed 15 June 2025
9. ---. “Serotonin, Amygdala and Fear: Assembling the Puzzle.” *Frontiers in Neural Circuits*, vol.10, no. 24, 5 Apr. 2016, https://doi.org/10.3389/fncir.2016.00024.
10. “Neurotransmitters.” *Cleveland Clinic*, 14 Mar. 2022, my.clevelandclinic.org/health/articles/22513-neurotransmitters.
11. Bauer, Elizabeth P. “Serotonin in Fear Conditioning Processes.” *Behavioural Brain Research*, vol. 277, Jan. 2015, pp. 68–77, https://doi.org/10.1016/j.bbr.2014.07.028. Accessed 4 Nov. 2019.
12. Tortora, Francesco, et al. “The Role of Serotonin in Fear Learning and Memory: A Systematic Review of Human Studies.” *Brain Sciences*, vol. 13, no. 8, 1 Aug. 2023, p. 1197, www.mdpi.com/2076-3425/13/8/1197, https://doi.org/10.3390/brainsci13081197.
13. Johnson, Luke R., et al. “Regulation of the Fear Network by Mediators of Stress: NorepinephrineAlters the Balance between Cortical and Subcortical Afferent Excitation of the Lateral Amygdala.” *Frontiers in Behavioral Neuroscience*, vol. 5, 2011, https://doi.org/10.3389/fnbeh.2011.00023. Accessed 17 Jan. 2022.