Trauma and the Brain

There are many different areas, neural pathways, and neurotransmitters (brain chemicals) in our brains that go into each thought, feeling, and behavior that we experience or engage in. Fortunately, neuroscience and neuroimaging has given us a peek into the inner workings of ourselves. This handout is a brief overview of the anatomy and physiology of our brains for the purpose of understanding the impact of trauma.

Neuroanatomy—The Triune Brain Model

A commonly known model of the brain is the "triune brain model", which breaks the brain down into three main areas of functioning:

1. The brainstem, often referred to as the "Primitive/Reptilian Brain"

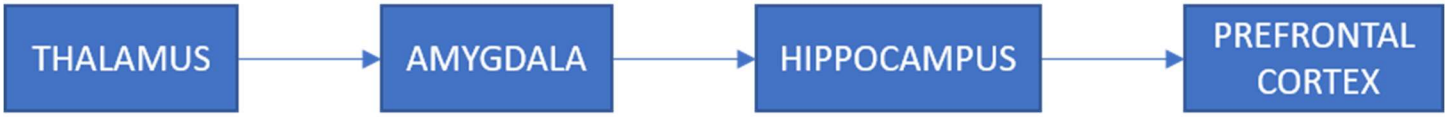
2. The limbic area, often referred to as the "Emotional/Mammalian Brain"

3. The cortex, often referred to as the "Thinking/Human Brain"

The brain develops from the "bottom-up"—the brainstem begins developing in utero, the limbic area during the first several years of life, and the cortex continues to develop and adapt until early adulthood. Trauma can impact the brain and its development at any point in time.

The brainstem regulates basic "housekeeping" in the brain—involuntary and instinctual responses such as reflex behaviors, muscle control, breathing, heartbeat, and balance. This is also the area of the brain associated with **freeze** responses.

The limbic area is the middle part of the brain that perceives, categorizes, checks for danger, and experiences emotions. It houses the thalamus, amygdala, hippocampus, and anterior cingulate cortex (ACC).



This is the typical flow of processing information in the brain.

The thalamus acts as the "switchboard" for the brain—all messages it receives through your five senses come to the thalamus first, which decides where the information should go next. The amygdala is a part of the limbic area deep inside our brain, serving as its fear center. This subcortical area is outside of our conscious awareness or control, and its primary job is to receive all incoming information – everything you see, hear, touch, smell, and taste – and answer one question: "Is this a threat?" When this area is activated, we feel afraid, reactive, and/or vigilant (**fight** or **flight**).

Next, perceived information flows to the hippocampus—the "memory filing cabinet" of your brain. The hippocampus takes new information and runs it by previously stored memories and experiences for similarities.

The anterior cingulate cortex (ACC) is what is known as the emotion regulation center—located next to the prefrontal cortex, but deeper inside the brain. This area is responsible for regulating emotion closely with the "Thinking Brain". When this region has been strengthened, we are able to manage difficult thoughts and emotions without being totally overwhelmed by them. While we might want to send a snarky email to a coworker, the emotion regulation center reminds us that this is not a good idea, and helps us manage our emotions so that we don't do things we regret.

The cortex takes up the whole top layer of your brain. An important subarea is the prefrontal cortex, or "Thinking Brain". It is located near the top of your head, behind your forehead. It's responsible for abilities including rational thought, speech, sense of time, problem-solving, personality, planning, empathy, and awareness of ourselves and others—basically, the qualities that make humans unique from other mammals! When this area of the brain has been strengthened, we are able to think clearly, be confident in our decisions, and be aware of ourselves and others.

Physiological Responses

There are two important parts of your nervous system that play an important role in your body's physiological responses to these kinds of events. In turn, the physiological responses in your body also have an impact on the functions your brain is prepared to perform. When the brain's alarm system is turned on, we go into "survival mode" (**flight**, **fright**, or **freeze**), and automatically experience preset physiological responses set in the brainstem and limbic area—particularly involving the ACC, amygdala, and hippocampus. It often takes the prefrontal cortex a little while to catch up. Over time, this can change with cognitive and body-based therapy techniques.

The **parasympathetic nervous system** is responsible for the "rest-and-digest" response. In the absence of any warning signals, this part of your nervous system restores the body to balance, allowing it to restore and repair itself. You may notice a slower heart rate, slow and deep breaths, and relaxed muscles. The parasympathetic response helps improve digestion, conserve energy, and maintain overall health.

The **sympathetic nervous system** controls the "fight-or-flight" response. When the "warning signal" system in the brain is activated, the hippocampus (the "memory filing cabinet" of the brain) changes from encoding and consolidating memories to pumping cortisol (stress hormone) in the body to prepare for a fight (physical challenge) or flight (escape/retreat) responses. This hormone activates targeted organs and muscles, ensuring that you are active and alert in order to survive. You may notice that heart rate increases, breath quickens, and muscles contract. Another common response is the "freeze" response—complete immobilization or inability to respond.

Your Brain on Trauma

Traumatized brains look different from non-traumatized brains in three fairly predictable ways:

1. The prefrontal cortex/rational or thinking brain is under-activated

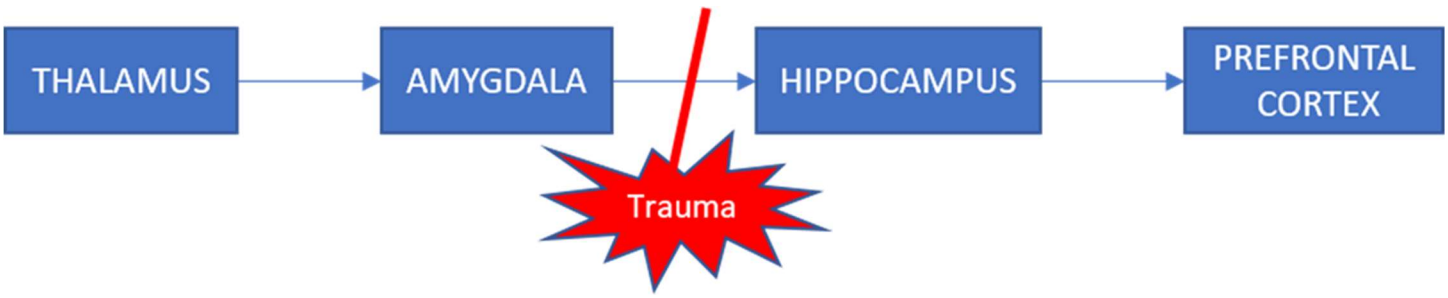
2. The anterior cingulate cortex/emotion regulation center is under-activated

3. The amygdala/fear center is *over-activated*

A traumatized brain is "bottom-heavy," meaning that activations of lower, more primitive areas (like the limbic system and brainstem) are high, while higher areas of the brain (also known as cortical areas) are under-activated. In other words, if you are traumatized, you may experience chronic stress, vigilance, fear, and irritation. You may also have a hard time feeling safe, calming down, or sleeping. These symptoms are all the result of a hyperactive amygdala.

At the same time, individuals who are traumatized may notice difficulties with concentration and attention, and often report they can't think clearly. This is due to the thinking center being under-activated.

Survivors of trauma will sometimes explain that they feel incapable of managing their emotions. For example, if someone spooks them, they may experience a rapid heart rate long after the joke is up, or may have a hard time "just letting go" of minor annoyances. Even when they want to calm down and feel better, they can't. This is in large part due to an under-activated emotion regulation center.



How traumatic experiences impact the flow of processing information in the brain.

Traumatic experiences are encoded in the brain differently because the brain is in a fight-flight-or-freeze response at the time. When the amygdala senses danger, the brain stops the processing progression and prepares for flight-fight-freeze responses. Your brain releases extra vasopressin and norepinephrine, which provide natural pain relief, additional strength, and slight amnesia. *There are often no words to attach to traumatic experiences because the center for speech production is in the prefrontal cortex.*

What makes traumatic memories different than everyday memories?

Because the hippocampus switches from encoding and storing memories to pumping cortisol, processing of stress- or trauma-related memories is rerouted. As a result, it difficult to consciously access these memories—they're not in the place in the brain where you'd usually find them. Think of a time when you placed something important (like your keys or wallet) in a different place than you normally do—it was probably very difficult to remember where the item was and you may have stumbled back on it when you least expected it!

Everyday memories	Traumatic memories
Narrative form—there is a beginning, middle, and end	Non-linear—story may be incomplete, or have no sense of time or order attached
Context makes sense (no "missing puzzle pieces")	Memories may be fragmented—"missing puzzle pieces"
Easily verbalized	May be difficult to verbalize
Emotions associated with remembering are not overwhelming	Emotions associated with remembering can be overwhelming

So, what now??

Changing the brain takes effort, repetition, and time. A therapist who specializes in trauma and PTSD and uses evidence-based methods that change the brain by working with both the body and the mind can help you make and sustain these changes when you are ready.

Consider adding a body-based or mindfulness-based technique to your daily routine, to help begin deactivating the fear center. Talk with your therapist about how to explore different grounding and relaxation techniques that can help you manage stress- and trauma-related responses. This is a vital first step to healing—when we are able to quiet the fear center, we are better able to work on strengthening and activating the thinking and emotion regulation centers of the brain. Two such exercises include diaphragmatic breathing and autogenic training (self-produced physical relaxation). Remember, practice makes progress!

References

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