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The Neuroscience of Trauma

Neuroscience research is helping us peer inside the brain to understand how psychological trauma is associated with multiple types of brain change, including alterations in brain activation, volume of structures, connectivity among key brain regions, brain waves, and neurochemicals. Additionally, brain change can be inferred using psychophysiological approaches, which can inform researchers about various indices of stress and, indirectly, some types of brain activity. When treating trauma, it is possible to reference research examining brain change from several different perspectives.

What's really happening in the brain when someone experiences trauma? This workbook focuses primarily on brain activations associated with psychological trauma, drawing from both neuroimaging and psychophysiological research. Five key brain areas involved in trauma are emphasized, and techniques that have been shown to alter the activation of these brain areas are presented in the *Trauma Treatment Toolbox*.

YOUR BRAIN ON TRAUMA

As you explore the five main brain areas implicated in trauma that are described briefly below, keep in mind that none of these areas is isolated or works alone. There is connectivity between all of these areas, and trauma recovery helps to increase connectivity and create a more integrated brain.

1. **Fear Center (Amygdala):** The main objective of the amygdala is to determine whether a particular situation, context, person, etc. presents a threat or danger. It's an area that has been called the "smoke alarm" by trauma expert Dr. Bessel van der Kolk and colleagues (van der Kolk, McFarlane, & Weisaeth, 1996). One goal of trauma treatment is to reduce activation of this area of the brain. De-activation of this area can reduce reactivity to trauma triggers and the arousal and reactivity symptoms of PTSD (such as hypervigilance, feeling on guard, etc.).
2. **Interoception Center (Insula):** The insula is the main site of interoception and proprioception. Proprioception involves one's sense of balance and awareness of where the body is located in space. For example, the ability to walk and know where your legs and body are positioned—even with your eyes closed—is possible because of proprioception. Without this ability, one might just fall down. Interoception is one's ability feel into internal experience and connect with internal sensations. For instance, feeling hungry, warm, or jittery are all examples of interoception. In trauma, the insula is often dysregulated, which makes it difficult to identify and manage emotions and distressing physical sensations. When the insula is strong, individuals are better able to feel into their own bodies, identify the emotions they are experiencing, and regulate them.
3. **Memory Center (Hippocampus):** The hippocampus is known as the memory center of the brain. It is also sometimes called the "timekeeper" (van der Kolk, 2014), since it is responsible for putting a time stamp on our memories. This allows us to experience past events as happening in the past, not the present. In individuals who experience post-trauma symptoms, it is often the case that this area

of the brain is less active, and smaller, than those of individuals who have not experienced trauma or an anxiety disorder. This results in memory and stress regulation difficulties. Increased activation of this area of the brain helps individuals feel safe in the present moment, and can help reduce fear when trauma triggers occur.

4. **Thinking Center (Prefrontal Cortex)**: The prefrontal cortex (PFC) is comprised of several smaller structures, which together are considered the thinking center of the brain. The PFC is involved in functions such as concentration, decision-making, self-awareness, and awareness of others. In traumatized brains, however, it is common for this area of the brain to be underactive, making it difficult for individuals to concentrate, make decisions, connect with others, and be self-aware. Increased activation of the PFC leads to clearer thinking, improved concentration, a sense of connectedness to others, and better self-awareness.
5. **Self-Regulation Center (Cingulate Cortex):** The cingulate cortex, and more specifically, the anterior cingulate cortex (ACC) or dorsal anterior cingulate cortex (dACC), is involved in conflict monitoring, error detection, and self-regulation, including regulation of emotion and thoughts. This area of the brain is often underactive in individuals experiencing post-trauma sequelae, which can result in difficulties with emotion regulation, thought regulation, and decision-making. Increased activation of this area can be immensely helpful, as it improves individuals' abilities to regulate unhelpful or painful emotions and manage distressing thoughts.

Additionally, connectivity between these key brain areas can impact an individual's symptoms and functioning in a positive way. Below, some basic information regarding neural connectivity is provided:

- **Cortical-Subcortical Connectivity:** Connections between the self-regulation/thinking areas of the brain (prefrontal cortex and cingulate cortex) and the fear brain (amygdala) can allow for down-regulation of the amygdala, thereby reducing fear responses and negative emotions. This can be thought of as turning off or quieting the alarm on the brain's smoke detector.
- **Insular Connectivity:** When bidirectional connections between the amygdala and insula are strong, it leads to exaggerated fear responses. This is because the insula detects aversive bodily sensations and then communicates this to the amygdala (fear center), which may then catastrophize those sensations.

THE BRAIN ON TRAUMA

The five key areas of the brain include the amygdala (fear center), insula (interoception center), hippocampus (memory center), prefrontal cortex (thinking center), and cingulate cortex (self–regulation center). Each of these areas, and the key connections among them, are shown on the next page.