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The Biology of Trauma

A person is walking through the forest when suddenly a giant tiger crosses his path.
The person responds with fear, perhaps shock.
His heart pounds.
Cold sweat covers his body.
For a moment he feels helplessness.
He can't decide what to do.
Perhaps he should flee,
Or perhaps he should freeze in place.

These are the immediate, natural responses to a threatening situation. But what happens next? The tiger disappears but how does its disappearance effect the person? Will he now avoid walking through the forest? Or in forests in general? Perhaps he will be too frightened to leave his house, even to go out onto the street? When he sees a tiger on television will he feel as if he is reliving the frightening encounter in the forest? Perhaps it will happen when he sees a cat? Or will the threatening experience return again and again without any external stimulation? Will it again be accompanied by a pounding heart and perspiration? Will he feel angry? Lucky? Helpless? Will he withdraw into himself? Would he feel trampled and threatened all the time? Or will the become disconnected and alienated?

The answers to these questions are also answers to questions of whether or not this person will develop Post-Traumatic Stress Disorder (P.T.S.D.) If we recognize the biological mechanisms for dealing with threat, we can understand both these natural responses and also what happens when P.T.S.D. develops. (Diagram #1.)

Coping with threat

When we are exposed to a traumatic event, we perceive it via our senses: we see the tiger, we hear its steps and heavy breathing, we smell his scent and sometimes even in… feel his touch. The information is transmitted from our sensory organs to the brain. Sensory perceptions are transmitted to a section of the brain called the thalamus and from there to two additional areas, the cortex and amygdale.

The amygdale are the brains "alarm system," which is activated by any threat, gives it the emotional tag "fear" and then transmits information to four systems:

Memory-Creation System

The amygdale transmits the warning to the hippocampus, which helps provide words for the personal, emotional experience and in creating the proper attitude towards it. For example, "In this forest there is a danger that I will encounter a tiger." This is how the memory of the event is created.

From the hippocampus, the information is transmitted to the cortex where, particularly in the area called the "prefrontal cortex," the overall experience is evaluated, in light of the person's previous life experience. At the end of the process, if the threat passes, an "all-clear" signal is sent from the cortex to the amygdale and the experiences is "filed" as an experience from the past.

The Sympathetic Nervous System

From the amygdale, the information also reaches the brain stem, where an order is given to secrete the hormone neuroadrenaline, which reaches all of the body's organs and instructs them to prepare for a dangerous situation (to accelerate the pulse in order to supply more energy and oxygen, to perspire so that it will be harder for the attacker to take hold, etc.) When the neuroadrenaline level is too high, the brain stem[1] will know this and give an order to halt the secretion.

The Hormonal System

From the amygdale, the information also reaches the hypothalamus, where it activates a multistage process that ends with the secretion of the hormone cortisol that ensure the supply of energy necessary to deal with the stressful situation. When the cortisol level is too high, the hypothalamus[2] acts to halt its secretion.

The Serotonin System

In the raphe nucleus, there are nerve cells that contain serotonin. When the hypothalamus transmits the information about the threat to this nucleus, it then secretes serotonin that reaches all of the brain structures involved in the response to stress (the cortex, hippocampus and amygdale). Secretion of serotonin regulates deceleration of the state of alarm and the return to a state of calm

Post-Traumatic Disorder

Until this point, we have reviewed the normal process for responding to a threat. In the case of people who suffer from P.T.S.D. something in this process has gone awry. The biological possibilities can be divided into two categories: anatomical findings related to the structure of the brain and the neuro-chemical findings related to the substances secreted in the brain.

Anatomical Findings

In research conducting using Magnetic Resonance Imaging (MRI), it was found that the volume of the hippocampus was smaller in people suffering from P.T.S.D., than in other people. It seems that the smaller hippocampus is indicative a deficiency in its functioning, which might explain why the conversion of the traumatic experience into memory is disrupted among people suffering from P.T.S.D. As a result, the event is repeatedly experienced as if it were occurring in the present and does not become a verbal memory that can be stored away as an event that occurred in the past.

An interesting finding is that a small hippocampus volume was found both in American combat soldiers who suffer from P.T.S.D. and in their identical twin brothers, who were not exposed to battles and who do not suffer from the disorder. This finding hints at the possibility that some people have an prior vulnerability for developing P.T.S.D. in the event that they are exposed to a trauma and that this vulnerability has a genetic basis. Other research conducted with the assistance of MRI imaging found that people suffer from post-traumatic shock syndrome also have a smaller prefrontal cortex.

In addition, studies using positron emission tomography (PET) imaging observed increased activity of the amygdale when responding to stimuli related to trauma (for example, when discharged combat soldiers were viewing war movies). The combination of disturbances in the functioning of the amygdale, hippocampus and prefrontal cortex can explain the unique nature of the penetrating memories experienced by people suffering from P.T.S.D. which continue for many years, are easily aroused by triggers (activating stimulants) and have an emotional character that is difficult to describe in words. Furthermore, symptoms such as the inability to remember parts of the traumatic event and the segmented nature of the memories can also be explained by disrupted functioning of these brain structures.

Neuro-Chemical Findings

Increased neuroadrenaline activity and damage to the negative feedback on its secretion in the brain stem are also found among people suffering from P.T.S.D. The result is that trivial stimuli cause a intense reaction of the sympathetic nervous system, for example a loud noise will cause a significant acceleration of the heart rate. People suffering from this disorder also have a low level of cortisol, which sabotages their ability to respond appropriately when threatened.

People suffering from P.T.S.D who have been treatment with Paroxetine (a medication that acts on the serotonin system) have been observed to have growth in the hippocampus and improved functioning on memory test. The therapeutic effectiveness of selective serotonin reuptake inhibitors (SSRI) also testifies to the involvement of the serotonin system. Furthermore, there is evidence of heightened activity of the pain relief system (the opiod system), a phenomenon which could explain the experience of dulled emotions that is characteristic of P.T.S.D. Similarly there is partial evidence for an increased arousal of the dopaminergic systems that might relate to symptoms of vigilance and suspiciousness.

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