

The Effects of Stress on Short-Term and Long-Term Memory

Marni Rossman

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Faculty Advisor: Srinivasan Mahadevan

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The brain is a complex structure at the center of our central nervous system. Comprised of billions of neurons, it is continually receiving and sending our signals to different body parts through our sympathetic and parasympathetic nervous system. Depending on various types of injury, illness, and stressors, the short term and or long term memory capacity may be deteriorated. Throughout this paper I will analyze the different causes and consequences of stress on the brain.

The central nervous system, containing both the brain and the spine, along with the peripheral nervous system control most of our every day functions. The brain is split into different lobes: the frontal, parietal, occipital and temporal lobe. The temporal lobe is most notably associated with the storage of memories. Of particular importance is the role the hippocampus, amygdala, and prefrontal cortex play in the brain when involved with both acute and chronic stress.

The hippocampus is the brain's main memory center. This paired structure is located in the medial portion of the temporal lobe and deals primarily with special memory and long term memory. It functions to process short term memory by converting it to long term memory. The amygdala, located deep in the temporal lobe, deals with emotional memory. This includes fear conditioning and memory consolidation. Lastly, the prefrontal cortex deals with more complex and goal orientated functioning. Located in the anterior portion of the

frontal lobe, the prefrontal cortex helps to keep the amygdala from overreacting to the stress response.

The different regions of the brain are affected differently by stress. These stressors may affect the short term and long term ability differently depending on the source of the stress, the duration of the stress, the intensity of the stress, and the timing that the stress occurs in the memory phase. Primarily, the limbic system deals with stress and anxiety. It had such a strong influence on memory and emotions that it is also known as the emotional brain. When an area of the brain is stimulated by stress, the limbic system responds through the autonomic nervous system through its endocrine glands that automatically help to control our metabolic system (The Franklin Institute).

It is also important to distinguish between the different types of memory: short term memory and long term memory. Short term memory, also known as active memory, lasts for only a matter of seconds. It holds information in the brain for short amounts of time, this way keeping the information readily accessible. Our memory span for our short term memory is very limited, although there are ways to help convert short term memory to long term memory.

Long term memory may last from a few days to decades. This includes episodic, semantic, and procedural memory. With episodic memory we are able to recall specific dates and events in time. This usually includes personal experiences. Our semantic memory helps us to recall knowledge about our external world. This is generally facts and rules about general information. Lastly, procedural memory includes remembering the order for performing specific tasks.

There are many chemicals involved with the stress response in the human body. Glucocorticoids are steroids that are made in the adrenal gland. The primary glucocorticoid released when the body perceives a threat is cortisol. When the brain tries to send a signal out to the body, cortisol will interfere with the ability of the neurotransmitters to communicate. This, therefore, makes it difficult to retrieve information from our long term memory (Your Amazing Brain).

Cortisol is released through an elaborate process. First, the hypothalamus signals to the pituitary gland (located at the bottom of the brain) to release chemicals that. Within only a matter of minutes, those chemicals reaches the adrenal cortex. They then tell the adrenal cortex to secrete cortisol, which is then distributed throughout your body through your bloodstream (Your Amazing Brain).

Other important chemicals in the stress response include corticotrophin and epinephrine. Corticotrophin is secreted in the hypothalamus in response to stress and anxiety. Epinephrine is a type of adrenaline. The Adrenal glands release epinephrine to tell the body to increase its breathing, heart rate, and blood pressure (The Franklin Institute). This, therefore, moves along more oxygen to the brain and muscles allowing the sympathetic “fight or flight” response to occur.

After a certain amount of cortisol has been released into the body, the body tells itself it needs to rid itself of the steroid. Hormones are then secreted and sent to go to the adrenal glands and the brain to retrieve the excess cortisol. The hormones then transport the excess cortisol to the kidneys to remove it from the body, therefore returning the body to more of a state of equilibrium (The Franklin Institute).

The Yerkes-Dodson law reveals the relationship between stress and memory. With a low amount of stress, memory formation does get better. Once it reaches a certain level and the amount of stress becomes too high, the ability to form and recall memories from ones long term and short term memory becomes debilitated. This demonstrates why concluding whether or not an event will become a memory depends on the levels of stress around the time of the event (Lukowiak).

With short term stress, one may experience physiological changes that enhances behavior and helps to override challenge. Once that stress becomes chronic, those same physiological changes that enhanced behavior become detrimental to one's body. This is due to the activation of the hypothalamic, pituitary, and adrenal glands of the body that cause the secretion of cortisol in response to stress (Cazacoff).

When one really starts to notice the effects of stress on the brain is when it has encountered a form of chronic stress. This causes an over secretion of the stress hormone, as it goes out to collect the excess cortisol in the body. When the body encounters an adrenaline rush, it also comes across hypertension (an increased level of blood pressure), increased abdominal fat, and decreased bone density, all of which are detrimental to the body (The Franklin Institute). This is when our parasympathetic and sympathetic nervous system come into play, as the parasympathetic fights for the body to rest and digest and the sympathetic nervous system prepares the body for a fight or flight response.

This overexposure to chronic stress is what is proven to cause damage to the brain, especially the hippocampus. Once the hypothalamus detects a threat, it causes the pituitary gland to secrete a hormone which in turn causes the adrenal glands to secrete cortisol. Once the amount of cortisol in the body reaches a certain level, the hippocampus tells the

hypothalamus to turn off the mechanism causing the secretion of the cortisol. Once the brain has been over affected by the effects of the cortisol the hippocampus may become damaged through neuron death (Cheryl).

This damage to the hippocampus causes it to be unable to provide the proper feedback loop to the hypothalamus needed to stop the secretion of the cortisol. Consequently, cortisol is continually secreted in the brain with no source to tell it to stop, leading to diminished memory (The Franklin Institute). This stress hormone also causes the amount of blood glucose reaching the muscles to be diverted, causing the amount of blood glucose (and therefore energy as well) reaching the hippocampus to be diminished as well (Your Amazing Brain).

In neuroimaging studies that look at the effects of the stress hormone on memory we find results leading to the conclusion that deteriorated memory does occur along with chronic stress. By raising the level of stress using stimulus material, such as pictures and film, or through social evaluative threat situations (also known as stress tasks), Anda van Stegeren was able to obtain neuroimaging of the brain during these responses to stress. He found that high levels of stress, leading to the release of high levels of cortisol throughout the body, led to impaired memory performance. Also found was that highly involved with this stress response were the amygdale and hippocampus (van Stegeren). These results prove further the correlation between high levels of stress and stress hormones with impaired memory retrieval in the brain.

In studies done on rats injected with cortisol, researchers found that after several weeks the rats did experience death of brain cells. Primary affected was the hippocampus, the area responsible for episodic memory (The Franklin Institute). There is also evidence of

reduced density of the hippocampal dendritic spines of rats due to stress (Chen). This gives only more evidence that the brain does experience diminished memory levels when overridden with the steroid cortisol.

In a study at the University of Zurich in 2000, McGaugh studied thirty-six healthy adults. He asked them each to memorize a list of sixty nouns that were each displayed for about five seconds on a computer screen. Half the subjects took a pill containing cortisone (a precursor of cortisol) while the other half took a placebo pill. The pill was either taken an hour before the first presentation, just after the word presentation, or an hour before the retention test. McGaugh found that the subjects who took the cortisone pill did in fact experience impaired memory, but only when taken an hour before the retention test. This leads to the conclusion that the stress hormone cortisol did affect the subjects' ability to recall old (but not recent) memories (The Franklin Institute). It is important to note that all chemicals in response to the stress hormones are not all negatively correlated. There is such a thing as good stress that has proven benefits for the body. For instance, norepinephrine, which is one of the primary excitatory neurotransmitters, is important in the creation of new memories (The Franklin Institute). What seems to be paramount in this process is limiting or managing the stress that reaches the sympathetic nervous system so that the body is not constantly aroused and sending out the message of "fight or flight", consequently releasing increased amounts of cortisol.

Overall we find that excessive stressors lead to the release of chemicals in the body that do seem to impair the long term and short term memory capacity. Although many studies have been performed on humans of largely ranging ages, it is important to continue

research in order to fully understand the types of stress and situations that lead to the different amounts of diminished memory in the brain.

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