The impact of mindfulness on developmental neurology

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Abstract:

As one of the fundamental missions and goals of the Share Love Fund, we are particularly interested in how various contemplative practices affect behavior and the neurophysiology that mediates and enables changes in our wellbeing and health.

Overview -

Stress is not necessarily a negative factor. It can be helpful for a burst of increased energy and concentration, such as while playing a competitive sport or speaking in public. However, when it is constant, as most of us experience daily, it begins to alter the brain. Chronic stress, such as being overworked or having disputes at home, can change the brain's size, shape, and function down to the genetic level. The origin of stress is the hypothalamic pituitary adrenal axis, a sequence of interactions between endocrine glands in the brain and the kidney that governs the body's response to stress. When the brain recognizes a stressful circumstance, the HPA axis is immediately engaged, and cortisol is released, preparing the body for immediate action. However, chronically elevated cortisol levels wreak havoc on the brain. Chronic stress, for instance, raises the activity level and the number of neuronal connections in the amygdala, the fear region of the brain.

Moreover, when cortisol levels increase, electrochemical impulses in the hippocampus, the region of the brain responsible for learning, memory, and stress regulation, degrade. Also, in humans, activation of the hypothalamic-pituitary-adrenal (HPA) axis and the subsequent release of corticotropin-releasing hormone (CRH) from the hypothalamus, adrenocorticotropic hormone (ACTH) from the pituitary, and cortisol from the adrenal cortex are two of the most critical physiological markers of stress. That is not all, however. Cortisol can physically reduce the size of the brain. It causes the loss of synaptic connections between neurons and the shrinkage of the prefrontal cortex, the region of the brain that controls activities like concentration, decision-making, and social judgment. Cortisol also decreases the production of new brain cells in the hippocampus, thus implying that prolonged stress may make it more challenging to acquire and recall new information and lay the groundwork for more significant mental issues, such as depression and Alzheimer's disease. The effects of stress may penetrate the DNA of the brain. However, it is not all terrible news. There are several strategies to counteract the effects of cortisol on the stressed brain. The most effective weapons are exercise and meditation, which include deep breathing and concentration on the present moment. These two activities reduce stress and enhance the hippocampus's growth, enhancing memory.

Importance -

The brain is one of the human body's most unique and intricate parts. Even though this one organ is the seat of intellect, the interpreter of perceptions, the facilitator of physical movement, the regulator of behavior, and the prized possession of the human body, we still continually subject it to enormous stress. Though we have regulatory combatant systems in our body, the brain cannot only rely on them (cortisol) for its aid. Instead of just living with the stress, we turn to mindfulness

exercises: as the primary outside assistance in dealing with anxiety, stress, and loneliness.

An individual practicing mindfulness meditation focuses on a particular bodily function, usually their breath. The person is trained to concentrate on the changing sensations of their breathing, and when their mind wanders—not if, but when—they are taught to acknowledge the distractions for what they are and to simply let them go without passing judgment on themselves or the distraction by returning their attention to the breath. Remarkably, despite this practice being in use for more than 4500 years, we are just now beginning to understand how profoundly these practices can enhance our wellbeing in a self-regulatory, non-pharmaceutical fashion.

Discovery -

The central nervous system can be severely impacted by stress, which can also result in the emergence of neurological and psychological pathologies. Therefore, it is crucial to understand how cognitive neuroscientists use multiple techniques to better appreciate how practices like mindfulness and compassion-based meditation impact our health and how our brain and basic physiology undergo these processes. Due to the rapid advancement in neurological and behavioral science research and the creation of new study methodologies, scientists have learned more about the brain in the last ten years than they have in all preceding centuries. With these newly developed methods, such as neural imaging machines, we can truly understand how these practices impact our wellbeing. Furthermore, there are proven data/findings that have successfully identified what specific brain regions are associated with practicing meditation, how they reduce stress, and how they impact anxiety and depression.

Self-report evaluations, observations of behavior, or physiological measures are ways psychological stress reactions may be quantified and analyzed. These responses include those triggered by stressful stimuli, such as emotions, thoughts, behaviors, and physiological reactions. Based on clinical trials and acquired findings, it is understood that practicing meditation daily for only 20 minutes can considerably lower state stress, tension, disorientation, melancholy, fatigue, and increase optimism. Statistically speaking, anxiety can be reduced by a shocking 22% on average during a 20-minute meditation session. To delve deeper and analyze the neurological impacts of meditation, scientists use a technique called Functional Magnetic Resonance Imaging, more commonly known as fMRI.

Researchers interpret functional MRI images as maps representing the degree of cellular activity in a particular portion or region of the brain. In functional MRI research, scientists contrast numerous scans of an individual or many subjects. Such studies, like any research involving the comparison of multiple individuals, include varying conditions-- for example, the scans taken of an individual at rest compared to the scans taken of an individual solving a math problem, would allow researchers to identify which specific regions of the brain the individual activates to perform such mental tasks (i.e., writing, calculating). Studies of people from different groups—for instance, drug addicts and non-addicts—can show variations in the brain areas the two groups employ to carry out similar activities or react to stimuli or exposures.

fMRI Implications -

An fMRI detects changes in the local magnetic field from variations in the oxygenated to deoxygenated hemoglobin ratio in arterial blood vessels found in specific brain areas during a cognitive task. Given that brain cells, like other cells in the body, require oxygen as fuel, interpreting these variations as cellular activity stands to reason. As cellular activity in the brain increases, they require more oxygen; arterial blood vessels supply the area with more oxygenated hemoglobin. fMRI implicates the biological fact that more oxygen-carrying hemoglobin molecules will be present in the blood vessels that supply an

area where cells are using up more oxygen. To add, since the magnetic properties of the surrounding tissues are physically affected differently by hemoglobin molecules with oxygen molecules bonded to them compared to those without, the fMRI machine's magnets and energy pulses may be adjusted to record these fluctuations, which allows researchers to create pictures in which variations in oxygen concentration are visible as tonal or color variations. This beneficial technique is referred to as BOLD (blood oxygen level dependent) contrast.

Neurological Effects -

The brain's capacity to manage thoughts and emotions is thus impaired when someone is stressed out or nervous. Using fMRI scans taken during the period where an individual is stressed, we can determine that the prefrontal cortex and the anterior cingulate cortex, which are frontal brain areas, are inactive due to increased stress levels. They become inactive because they cannot regulate or manage their thoughts, fears, or anxieties. The posterior cingulate cortex is a different part of the brain that is quite active while under stress or worry; this is the part of the brain where self-referential, daydreaming, and other internal thoughts are related. In contrast, scans taken just a few minutes after a brief meditation session depicted significantly lower anxiety levels accompanied by increased activity in the previously stated brain areas. Anxiety reductions resulted from the deactivation of the posterior cingulate cortex and higher activation in the anterior cingulate and prefrontal cortex.

In addition to the activity of the anterior cingulate cortex, it is essential to note its connection to a different part of the brain called the amygdala (the center for motivation, emotional behavior, and integration of emotions) and how mindfulness can reduce stress by attenuating the connection between these two regions of the brain. The disruption in connectivity between the two regions results in the reduction of the activation and hyperactivity of the brain's emotional centers. Compared to relaxing approaches, practicing mindfulness meditation had far more significant neural effects, thus supporting the finding that even sitting for a few minutes each day to self-regulate one's emotions may significantly enhance positive feelings.

Effects of early life stress -

A wide range of negative impacts on development has been linked to early adversity, childhood trauma, or early life stress, all related to chronic or excessive stress in childhood. Many neurological systems have been linked to detrimental impacts from early life stress, but the processes through which early life stress influences development and individual differences in children's outcomes are still not fully known.

A child's brain chemistry, anatomy, and gene expression can all be altered by toxic stress. There are long-term consequences for a child's growing brain when toxic stress damages the brain's architecture. The Hypothalamic Pituitary and Adrenal (HPA) hormone axis is overactivated when a kid endures toxic stress. Consequently, stress hormone cortisol levels rise, which can have long-term effects on immune function and inflammation. Toxic stress has been linked to alterations in the anatomy of the brain.

Prefrontal–hypothalamic–[the] amygdala and dopaminergic circuits are at least partially affected by changes in the hypothalamic–pituitary–adrenal axis function by early life stress that is chronic and widespread. In contrast, this study has generally used techniques of evaluation that focus on children's exposure to events. Additional insight into the mechanisms leading to individual variations in early life stress-induced neurodevelopmental impacts may be gained by assessing variables influencing children's processing of stressors. Understanding how these neurobiological alterations affect development and increase the likelihood of psychopathology and health problems might be helped in this way.
The amygdala, prefrontal cortex (PFC), and hippocampal regions of the human brain undergo

comparable structural and functional changes after exposure to stress as children. A reduction in hippocampus volume is one of the most consistent results among children exposed to early life stress. As a result of early life stressors such as abuse, neglect, and poverty, children's hippocampus volume is reduced. This has been related to an increase in psychopathological symptoms. Stress in children's early lives is also suggested to alter hippocampal volume, affecting learning. It has been found that early life stress is linked to changes in the amygdala and PFC responsiveness to emotional stimuli and alterations in the connection between these areas. The amygdala's heightened susceptibility to emotional pictures has been linked to various stressors, including severe neglect and abuse in early institutionalization. This enhanced sensitivity to emotionally salient signals appears to be partially caused by altered PFC–amygdala connection. Children who have been physically or emotionally abused or have grown up in poverty tend to have abnormal connections between the amygdala and the inferior frontal gyrus. These connections appear to be more pronounced for children who were maltreated. For example, children exposed to various early life trauma show an abnormal trajectory of age-related alterations in the connection between the anterior cingulate cortex (PFC) and the amygdala (AAC). Adverse childhood experiences tend to influence the strength of PFC–amygdala connection, affecting anxiety and depressive symptoms.

Early life stress may alter the structure and function of the PFC–hippocampus–amygdala circuits, which alters the link between early childhood stress and its impact on neurological development.

As previously said, there is still a great deal we do not know about how stress in early childhood affects the PFC, the amygdala, and the dopaminergic reward system, all of which can alter learning and behavior and raise the risk of mental and physical health problems and disease. Even more so, researchers are still unsure which alterations are most significant for different health risks and what supports individual variances in children's outcomes following stressful events in early childhood. In addition to the elements discussed above, it is possible that other influences on children's neurobiological responses to stress may not have been considered while developing the conceptual frameworks for understanding early life stress described above**.** Nonetheless, it is concluded that (increased) exposure to stress at an early age can severely affect a child's neurological development.

Overthinking-

Experts estimate that we average between 2,500 and 3,000 thoughts every hour. Approximately fifty each minute, one per second. Does it imply that every individual is an "overthinker"? Overthinking, also known as rumination, is when one repeatedly concentrates on the same topic or scenario to the point that it interferes with one's life. Typically, there are two types of overthinking: dwelling on the past and worrying about the future. Someone struggling with over-thinking might feel "stuck" or incapable of taking action. It might be challenging to clear one's mind and concentrate on anything else. Sometimes, overthinking might even make matters worse. So why do we overthink? We overthink for a variety of reasons: it has become a daily routine, it may stem from anxiety, stress, or perfectionism, it might become an excuse for postponing or avoiding action, it may be a learned response from early-life encounters with adversity, and similarly to anxiousness, it can be a symptom of a creative mind.

Overthinking is frequently related to mental health issues such as depression, anxiety, post-traumatic stress disorder, and borderline personality disorder. Since over-thinking is linked to increased stress, anxiety, and depression, it will also affect similar parts of the brain, specifically the cerebral cortex and the amygdala. One part (the cortex) processes information in the form of

thoughts and imaginations, and the other part (amygdala) stimulates the emotional reactions to these thoughts, ultimately fear and anger. Since they go hand in hand, the cortex can influence the amygdala, and the amygdala can also significantly impact the cortex. Therefore, overthinking develops as a result of a vicious loop that begins with the development of fear and is then exacerbated by that fear, which leads to an endless cycle of negative thinking.

A better way to look at overthinking is to view it as the result of an unmet underlying desire. In doing this, thoughts should be thoroughly observed and considered neutral. This approach goes hand in hand with mindfulness as it teaches one to be aware of their ideas and let them pass, to realize that they are only thoughts; this helps one realize that their thoughts have no significance for their identity.

Cognitive fusion-

Cognitive fusion is the process of associating a thought with an experience. Cognitive fusion is often viewed as having negative impacts as it can impede the behavior of those with specific psychological issues. Negative thoughts can inhibit individuals with anxiety and depression from engaging in constructive behavior. A person who suffers from depression and is preoccupied with feelings of worthlessness due to their inability to triumph over their sadness may continue to reject getting help owing to the anticipated repercussions of doing so. Anxiety-afflicted individuals are also caught by cognitive fusion when, for example, they feel they would panic if exposed to stressful events and avoid all situations that may produce stress, even if they are essential for recovery. Ideas manifest into reality. When experiencing cognitive fusion, one feels detached from the world beyond their thoughts, sensations, actions, and even other people. However, cognitive fusion and overthinking are beneficial in several ways as they are necessary for specific scenarios. When faced with significant and challenging decisions, such as which job route to pursue or whom to marry, we must replicate future situations as realistically as possible, resulting in an in-depth thought process and inevitably overthinking -- and if someone has coped with excessive overthinking to the point that it threatens their health and life happiness, then definitely some course of action must be taken: cognitive defusion.

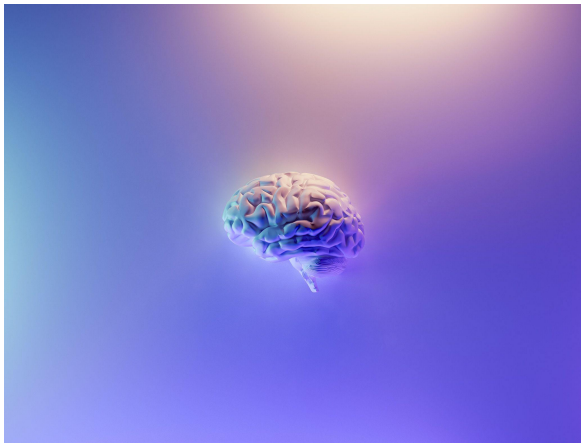
Cognitive defusion/ACT-

Acceptance and Commitment Therapy (ACT) employs cognitive defusion, also known as deliteralization, to assist patients in dealing with troubling or counterproductive ideas and feelings. People suffering from depression or anxiety might benefit from this method since they often deal with intrusive and unwanted thoughts and sensations. As the name suggests, cognitive defusion entails constructing a buffer between ourselves and our ideas and emotions. Cognitive defusion is a valuable tool to understand our ideas' power better. When dealing with mental health concerns, it might feel like we have no control over our thoughts or feelings. They can even convince us that we will never be happy or optimistic in our entire life. We are so accustomed to taking our ideas and sentiments at face value in our daily lives that we do not consider them. It is important to remember that our thoughts have a negative slant and that we cannot accept them as 100% real all the time while we are coping with anxiety and sadness. To sum, cognitive defusion, a branch of mindfulness wellbeing, is an excellent mental health strategy that will enable you to become a proactive thinker and take control of your brain.

Consensus -

Stress, overthinking, and cognitive overload are a few examples of the negative processes that the brain has to undergo. While the human body can maintain a healthy mental state for a given time, it does get complicated when there is increased forbearance in any of these processes. Therefore, it is essential to implement mindfulness in daily life;

even twenty minutes of practice, mindfulness- and compassion-based meditation may significantly reduce stress, anxiety, and loneliness.



References -

Witmer, S. A. (2021, July 12). *What Is Overthinking, and How Do I Stop Overthinking Everything?* GoodRx Health. https://www.goodrx.com/well-being/healthy-mind/how-can-i-stop-overthinking-everything

Office of Communications and Public Liaison (Ed.). (n.d.). *Brain Basics: Know Your Brain*. National Institute of Neurological Disorders and Stroke. Retrieved July 24, 2022, from https://www.ninds.nih.gov/health-information/patient-caregiver-education/brain-basics-know-your-brain#:~:text=The%20brain%20is%20the%20most,qualities%20that%20define%20our%20humanity.

Luders, E., Toga, A. W., Lepore, N., & Gaser, C. (2009). The underlying anatomical correlates of long-term meditation: Larger hippocampal and frontal volumes of gray matter. In *PMC3184843*. PMC. https://doi.org/10.1016/j.neuroimage.2008.12.061

Crosswell, A. D., & Lockwood, K. G. (2020, July 8). *Best practices for stress measurement: How to measure psychological stress in health research - PMC*. PubMed Central (PMC); www.ncbi.nlm.nih.gov. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7359652/#:~:text=Stress%20responses%20can%20be%20measured,instigated%20by%20the%20stressful%20stimuli.

National Institute of Neurological Disorders and Stroke. (2022, April 1). *Brain Basics: Know Your Brain | National Institute of Neurological Disorders and Stroke*. Brain Basics: Know Your Brain | National Institute of Neurological Disorders and Stroke; www.ninds.nih.gov. https://www.ninds.nih.gov/health-information/patient-caregiver-education/brain-basics-know-your-brain

Dedovic, K., Renwick, R., Mahani, N. K., Engert, V., Lupien, S. J., & Pruessner, J. C. (2005, September 0). *The Montreal Imaging Stress Task: using functional imaging to investigate the effects of perceiving and processing psychosocial stress in the human brain - PMC*. PubMed Central (PMC); www.ncbi.nlm.nih.gov. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1197276/

Limbic System: Amygdala (Section 4, Chapter 6) Neuroscience Online: An Electronic Textbook for the Neurosciences | Department of Neurobiology and Anatomy - The University of Texas Medical School at Houston. (2020, October 10). Limbic System: Amygdala (Section 4, Chapter 6) Neuroscience Online: An Electronic Textbook for the Neurosciences | Department of Neurobiology and Anatomy - The University of Texas Medical School at Houston; nba.uth.tmc.edu. https://nba.uth.tmc.edu/neuroscience/m/s4/chapter06.html#:~:text=Amygdala%20is%20the%20integrative%20center,the%20anterior%20of%20the%20hippocampus.

Smith, S. M., & Vale, W. W. (2006). The role of the hypothalamic-pituitary-adrenal axis in neuroendocrine responses to stress - PMC. In *Dialogues in Clinical Neuroscience* (Vol. 8). www.ncbi.nlm.nih.gov. https://doi.org/10.31887/DCNS.2006.8.4/ssmith

High Focus Centers. (2020, February 18). *What Is Cognitive Defusion? | High Focus Centers*. High Focus Centers; highfocuscenters.pyramidhealthcarepa.com. https://highfocuscenters.pyramidhealthcarepa.com/what-is-cognitive-defusion/

Gunarso, B. (2020, July 6). *The Right Way to Overthink. A scientific approach to deal with an… | by Bandoro Gunarso | Medium*. Medium; bandorogunarso.medium.com. https://bandorogunarso.medium.com/the-right-way-to-overthink-5991d4ea4506

Brown, J. (2021, September 15). *Why We Overthink and 8 Ways to Stop Overthinking*. No Worries Wellness LLC; noworrieswellness.org. https://noworrieswellness.org/noworries-blog/why-we-overthink-and-8-ways-to-stop-overthinking

Dorter, G. (2015, March 14). *Greg Dorter's Therapy Blog*. Greg Dorter Therapy Blog; www.guelphtherapist.ca. https://www.guelphtherapist.ca/blog/cognitive-fusion-defusion/

Becker, D. B. (2020, January 27). *The Power of Cognitive Defusion: How to Let Useless Thoughts Go and Improve Mental Health*. Blake Psychology; www.blakepsychology.com. https://www.blakepsychology.com/2020/01/the-power-of-cognitive-defusion-how-to-let-useless-thoughts-go-and-improve-mental-health/

Donna. (2008, 0 0). *Stress Management | MindfullyAware*. Stress Management | MindfullyAware; web.archive.org. http://web.archive.org/web/20190405155223/http://www.mindfully-aware.com/stress/

Test Anxiety Fact Sheet – Pathfinders for Autism. (n.d.). Test Anxiety Fact Sheet – Pathfinders for Autism; pathfindersforautism.org. Retrieved July 24, 2022, from https://pathfindersforautism.org/articles/education/test-anxiety-fact-sheet/

Recurrent Depression Tied to Smaller Hippocampus. (n.d.). Medindia; www.medindia.net. Retrieved July 24, 2022, from https://www.medindia.net/news/healthinfocus/recurrent-depression-tied-to-smaller-hippocampus-152892-1.htm

LaBracio, L. (2016, March 10). *How stress affects your brain (in TED-Ed GIFs)*. TED-Ed Blog; blog.ed.ted.com. https://blog.ed.ted.com/2016/03/10/how-stress-affects-your-brain-in-ted-ed-gifs/

Manchanda, G. (2021, June 2). *Here's How Stress Can Affect Your Brain and Body*. Eat My News; www.eatmy.news. https://www.eatmy.news/2021/06/heres-how-stress-can-affect-your-brain.html

Smith, K. E., & Pollak, S. D. (2020, December 16). *Early life stress and development: potential mechanisms for adverse outcomes - Journal of Neurodevelopmental Disorders*. BioMed Central; jneurodevdisorders.biomedcentral.com. https://jneurodevdisorders.biomedcentral.com/articles/10.1186/s11689-020-09337-y