The Mind's Design: The Neuroscience of Stress and Resilience

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Abstract: Resilience and the ability to manage stress contribute to life satisfaction and success. Resiliency contributes to academic and professional success, healthy interpersonal relationships, confidence in oneself, and is a positive predictor of life satisfaction. The body's stress response is a highly orchestrated biological action that can help or hinder resiliency. Understanding both the psychological and neuroscience components of stress and resiliency aids in understanding the "resilient person" prototype and offers insights into what interventions might increase the highly desired characteristic of resiliency.

Keywords: mindfulness, psychological resilience, resilience, stress, neuroscience

Stress is an unavoidable consequence of life and is at epidemic levels in American culture today. Definitions vary, but a commonly used definition of stress by the American Institute of Stress (2020b) is the "physical, mental, or emotion strain or tension" (para. 4). The global pandemic, an uncertain political future, and racial injustice add to the multitude of stressors faced by the American people in 2020. Now, more than ever, the importance of understanding and managing stress and increasing resilience is paramount.

Resilience contributes to academic and professional success, healthy interpersonal relationships, confidence in oneself, and is a positive predictor of life satisfaction (Roth & Herzberg, 2017). This article integrates research from neuroscience and positive psychology. It explores the neurobiology of the stress response, the consequences of excessive or chronic stress, the underpinning of biological variations in response to stress, the neuroscience of mindfulness and meditation. It presents an evidence-based framework for building resiliency. The article concludes with an immediately applicable neuroscience-based method for inducing the parasympathetic response to calm the body.

Literature Review

The literature is critically analyzed, synthesized, and integrated to share research insights into the fields of stress and resilience. Key search words included stress, stress response, resilience, psychological resilience, neuroscience, and mindfulness. Exploring the topics from both a biological and a psychological perspective presents a holistic approach to the topics and directly connects to satisfaction and success in everyday life.

Stress is essential to human survival and occurs on a continuum with positive and negative effects on the body. For immediate, short-duration stress can be beneficial to your health. When the brain detects risk and responds by instantly triggering the hormones and neurotransmitters of the stress response, the body prepares for immediate action. The benefits of stress extend past survival. Eustress, or "good stress," motivates and facilitates learning and change. Mild stress levels enhance attention and memory formation. The stress response positively stimulates the

immune system to ward off infections and heal from wounds (American Institute of Stress, 2020a). Conversely, sustained and chronic stress results in negative physiological and structural adaptations. Chronic stress wears down the body and results in irritability, anxiety, depression, and insomnia (American Institute of Stress, 2020b). An exploration of how the body and brain processes stress will explain this variance in stress' consequences.

Neuroscience of Stress

Stress is a well-researched topic in basic and clinical neuroscience. The last century of research provides a clear picture of its complex neuroanatomy and how homeostasis can be regained (Godoy et al., 2018). Scientists now understand the stress system as an engagement of the integrated brain structures that collectively detect and identify events as real or perceived threats (Godoy et al., 2018).

Stressors can be either physical, where one's physiological status is disrupted, or psychological, where a stimulus threatens in the present moment or can be anticipated to cause harm (Godoy et al., 2018). Physical and psychological stressors engage separate but potentially overlapping neural brain circuits. Physical stressors are processed primarily by the brainstem and hypothalamic regions. These encompass trauma to the body, infection, or blood loss. Psychological stressors are processed with the limbic system, including the prefrontal cortex. Upsetting events or the anticipation of such events are examples of such stressors. Conflicts, increasing professional demands, loss of a loved one, and financial strain are examples of prevalent psychological stressors.

When triggered by a stressor, the brain orchestrates a response. Two complementary biological pathways mediate the stress response: the autonomic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis. Within the autonomic nervous system, the sympathetic nervous system (SNS) is the first phase responder of the body's stress processing. This response occurs before conscious awareness and within a second of the brain's detection of the stressor. The sympathetic-adreno-medullar (SAM) axis activates the adrenal medulla of the adrenal glands (which sit on the kidneys), releasing adrenaline and noradrenaline into the bloodstream. The SNS provides a rapid response, activating the cardiovascular system and increasing alertness, vigilance, and the ability to appraise the situation (Godoy et al., 2018).

The second phase of the body's stress response engages the hypothalamus-pituitary-adrenal (HPA) axis. The HPA axis consists of the hypothalamus, the pituitary, and the adrenal cortex, where cortisol is produced. It intertwines the central nervous system and the endocrine system. Signals from the hypothalamus and pituitary release cortisol from the adrenal glands. The hypothalamus integrates body functions to maintain homeostasis. Cortisol, a steroid hormone, then crosses cell membranes to enter the brain to lock into its receptors. Cortisol signals back on the hypothalamus and pituitary gland to regulate cortisol's production.

All the body's cells host receptors for the hormone (King, 2016). Cortisol is known as the "Goldilocks hormone" because just the right amount is necessary for the body to be healthy. Two types of receptors in the brain regulate how quickly brain structures activate. High-affinity receptors have a six to tenfold higher affinity for the cortisol molecule. Those receptors are

activated faster and by smaller amounts of cortisol. The hippocampus, regulating memory and learning, and the amygdala, regulating emotions include these high-affinity receptors. They are activated by slight rises in the hormone and are more quickly affected than other brain regions (King, 2016). The frontal lobe, which regulates executive planning and control, has only low-affinity receptors. Activation in this region occurs later. The existence of these two receptor types explains why stress is both positive and negative. If only the high-affinity receptors are activated, memory and retrieval are enhanced. If the low-affinity receptors are activated, cognitive impairment results.

Stress duration is a contributing factor to whether stress acts as a positive or negative biological adaptation. Acute stress prompts the production of neural stem cells and increases the numbers of new neurons, which take at least two weeks to mature. These adaptations may occur due to a proactive response to future anticipated stress (King, 2016). Conversely, chronic stress minimizes new neurons and dendrites and suppresses new synaptic connections.

If stress hormones remain elevated for months or years, they can stimulate physiological changes. The hippocampus, critical to memory and learning, shrinks. The amygdala, critical to emotions, grows. Eventually, the complex feedback system that suppresses the excess secretion of cortisol is disturbed. Once this happens, the capacity to discriminate between threat levels falls away. Either everything seems threatening, resulting in anxiety, or else nothing does, with depression or burnout as a result.

Stress affects the body and brain differently at different periods of one's lifespan. The Harvard Center for the Developing Child (2014) reported that the stress response's neural circuits are remarkably malleable during the fetal and childhood period. Chronic or toxic stress in childhood disrupts the body's stress response system long term and may result in a system that is overactive or slow to shut down when faced with stress later in life. There are significant damaging effects on learning, behavior, and physical and mental health from this early stress.

Psychology and Neurobiology of Resilience

The word resilience, derived from the Latin verb *resilire*, means to "leap back" (Robertson et al., 2015, p. 534). Psychologists define resilience as the "process of adapting well in the face of adversity, trauma, tragedy, threats, or significant sources of stress—such as family and relationship problems, serious health problems, or workplace and financial stressors" (American Psychological Association, 2020, para. 4). Someone resilient has the capacity and adaptability to overcome stress and adversity while maintaining normal psychological and physical functioning (Wu et al., 2013). While the neurological understanding of resilience is in its infancy, research provides insights into the psychological, developmental, and genetic factors that influence the ability to adapt to adversity, change, and trauma.

Unique biological and personality characteristics, environmental aspects of family, community, and culture, and learned adaptations gained through life experiences shape an individual's resilience. The psychological personality traits studied by social scientists show the resilient prototype scores low on neuroticism and above average on extraversion, agreeableness, and conscientiousness (Roth & Herberg, 2017). Higher self-confidence levels, academic and

professional success, success in relationships, and better self-reported health characterize resilient individuals (Roth & Herzberg, 2017). Grit, the personality trait of perseverance and passion for long-term goals, is a predictor of one's resilience (Vainio & Daukantaitė, 2016). Duckworth et al. (2007) extensively studied grit and conclude that grit is the most reliable predictor of personal success.

Developmental factors contribute to resilience. Rodent and primate studies have consistently shown that maternal abuse in early childhood led to high anxiety levels and increased HPA Axis activity, resulting in delayed independence and diminished stress management skills later in life (Wu et al., 2013). Southwick et al. (2016) explored the effect of parents' well-being and child-rearing skills and the social support available from the community. Survivors of childhood trauma exhibit changes to the central nervous system (CNS) and reduced volume in the hippocampus, often observed in patients with mood disorders (Wu et al., 2013).

Genetic factors influence resilience. Variances in resilience are influenced by genetic variations identified in the Neuropeptide Y (NPY), the Hypothalamic-Pituitary-Adrenal Axis (HPA Axis), the noradrenergic and dopaminergic systems, and the serotonergic systems (Wu et al., 2013). The serotonin transporter (SERT) gene is regularly connected to increased mental illness rates and increased sensitivity to stress (Wankerl et al., 2014).

Research highlighted in Thomas Boyce's book, *The Orchid and The Dandelion,* presents an interesting theory on why some children thrive and others do not. He observed differences in a child's sensitivity to his or her environment. Boyce (2019) posited that most children demonstrate indifference to adversity and have stress response systems that react minimally to adverse experiences. Like the *wild dandelion* that grows out of a sidewalk crack, these children thrive. Other children are highly sensitive to both highly nurturing and highly traumatic experiences. Like the *delicate orchid*, these children can thrive in supportive settings but wither if the ideal conditions are not met. Boyce's research suggested that there may be some truth to being *born resilient*.

Learned adaptations refer to those behaviors obtained through attention, focus, and practice. These behaviors allow for tailoring to the environment. Psychological interventions to support and grow resiliency focus on skill development. These skills could include physical exercise, reframing thoughts and emotions, mindfulness, and social skills (Southwick et al., 2016). The awareness of one's perspective to life's challenges may prompt a focused and intentional strategy to gain coping skills.

Resilience clearly results from a multitude of factors. The notion that resilience is a binary variable, meaning one either has it or does not, denies its complexity. Resilience relies on behaviors, thoughts, and actions that one can develop (American Psychology Association, 2012). While biological and personality factors are outside of one's control, other factors, such as personality and learned adaptation, can increase resilience.

Research Approach

The exploration of stress and resilience draws on contemporary research from the fields of neuroscience and positive psychology. The purpose of this article is to understand resilience from a psychological and a biological perspective to solidify interventions to maximize resiliency. Research article subjects included mindfulness, psychological resilience, resiliency factors, stress, and stress response. The author selected articles due to their relevance to the article's topics and recent publication within the last five years.

Major Themes and Discussion of Resiliency

The stressful events of life are primarily outside of one's control. Resilience will determine how long one can continue to bend instead of break and how long one can sustain positive emotions. Self-awareness of the physical and emotional signs of chronic or excessive stress is essential to resilience. This increased self-awareness mitigates the adverse consequences of stress.

Previous notions that the ability to be resilient was inherent in some individuals and not others have been discounted. While resilience neuroscience research focuses on gene expression, the number of cells, and brain networks (King, 2016), other considerations must be factored in. This section presents a framework for building personal resilience and explores the widely recognized practices of meditation, mindfulness, and breath control.

Framework to Build Personal Resilience

A model of building resilience, offered by McKay (2020), presents practical interventions. In this building resilience model, three distinct factors are considered—bottom-up, outside-in, and top-down (McKay, 2020). Bottom-up factors include genetics and physical health. Without the ability to adjust genetic makeup, one can build resilience by positively influencing our physical health with a healthy diet, adequate sleep, and regular physical exercise. Outside-in factors include the social support structure. Those seeking to increase resilience should build networks of support. Benefiting from the love, care, and kindness of other people is one of the best ways to support oneself. Finally, top-down factors include our thoughts, beliefs, and emotions. Identifying and expressing emotions, controlling conscious thought patterns, and engaging in emotional regulation build resilience. This practical model offers a realistic and achievable plan to begin building resilience.

Mindfulness, Meditation, and Breath Control

Many individuals and wellness professionals tout the benefits of meditation and mindfulness to reduce psychological stress and stress-related health problems. The subjectivity of these ancient practices creates difficultly in research. A meta-analysis examined 47 trials including more than 31,000 participants explored meditation programs' efficacy in improving stress-related outcomes, including "anxiety, depression, stress/distress, positive mood, mental health-related quality of life, attention, substance use, eating habits, sleep, pain, and weight" in a diverse adult population (Goyal et al., 2014, p. 357). Mindfulness meditation programs had moderate evidence of improved anxiety, depression, and pain but insufficient evidence of improved stress/distress

and mental health-related quality of life. The meta-analysis found no influence or insufficient evidence of any effect of meditation programs on positive mood, attention, substance use, eating habits, sleep, and weight (Goyal et al., 2014). The researchers concluded that there was no evidence that meditation was better than any other treatment, including exercise, drugs, or behavioral therapies.

While the 2017 meta-analysis cannot promote meditation programs as beneficial to reducing stress and stress-related health problems, neuroscience research on breathing shows promise. The control of the breath has been used for centuries to promote mental calm and relaxation. Breathing functions both as an automatic function and one that can be manipulated by higher-order brain functions. The previously unexplored relationship between the breath and higher-level brain functions became the research topic of Stanford neuroscientists. A 2017 study presented evidence of a cluster of neurons in the brain stem contributing to alertness, attention, relaxation, and stress. This cluster of neurons communicates between the brain's respiratory control center and the structures responsible for generating arousal (Yackle et al., 2017). Understanding this cluster's function may lead to discoveries and strategies to alleviate stress, anxiety, and negative emotions through breath control.

Stanford neuroscientist and Principle Investigator of the Huberman Lab, Dr. Andrew Huberman, shared insight into how one can use breathing to change one's mental state. This calming breathing technique involves two short inhales, ideally through the nose, followed by one extended exhale, ideally through the mouth. It mirrors the natural sigh and is the most effective and quickest way to induce a sense of calm by activating the parasympathetic nervous system. Resilience is a quality worthy of continued exploration. Since resilience contributes to academic and professional success, healthy interpersonal relationships, confidence in oneself, and is a positive predictor of life satisfaction (Roth & Herzberg, 2017), the development of effective interventions will benefit society. This article aimed to understand stress and resilience from a psychological and a biological perspective and explore the researched interventions. The neuroscience of the body's stress response and a comprehensive understanding of stress formed the basis of exploring resilience. The author presented a holistic framework to build resilience. Finally, a breathing technique to engage the parasympathetic nervous system and induce a sense of calm concluded the article.

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