

Interventions of Neuroplasticity on the Brain: Neurogenesis, Emotional Psychology, and Human Behaviors

Joohee Seo

Abstract

This publication covers a range of topics at the intersection of neuroscience and psychology, including an analysis of neuroplasticity and cognitive function, the application of neuroplasticity in patients with neurodegenerative diseases, depression, anxiety, and substance abuse, adult neurogenesis, and emotional psychology and regulation. In addition, this publication highlights ethical considerations surrounding informed consent, appropriate disclosure, and relevant legislative and policy developments from an international perspective. The paper also explores the implications these research findings may carry for future investigators and for neurodivergent patient communities, with the aim of informing more clinically applicable research in the years ahead.

Introduction

Psychology is defined as the scientific study of the human mind and its functions, particularly those that shape behavior in a given context. Neuroscience, by contrast, examines how the nervous system develops, its structural organisation, and its functional mechanisms. Because human behavior and mental experience emerge from the biological architecture of the brain, neuroscience and psychology are deeply interrelated disciplines that together provide a more complete understanding of mental processes than either can offer alone. Greater insight into psychology, in turn, affords society improved access to frameworks for understanding mental health.

In the 19th century, psychologists Franz Gall and Carl Wernicke conducted foundational examinations of the brain, associating distinct regions with specific functions. Their work established a critical foundation for modern neuroscience as it continues to evolve. From these early advances, neuroplasticity emerged as a central concept, particularly within developmental psychology, for understanding how hereditary and environmental factors interact to shape the brain's capacity to adapt and rewire itself across the lifespan.

Discussion

Comprehensive Analysis of Neuroplasticity, Memory Functions, and Cognition

Researchers have been analysing the positive interventions of neuroplasticity on the mental health and well-being of patients. Investigators from the National Institutes of Health Blueprint for Neuroscience Research have made significant progress in both clinical therapies and empirical research examining how patients with mental and addictive disorders, developmental disorders, and cognitive decline can benefit from these interventions. In terms of the foundational mechanisms by which neuroplasticity enhances cognitive function, researchers have proposed that plasticity can facilitate early postnatal development through an oversupply of neuronal cells and synaptic connections. Brain plasticity has also been associated with spontaneous recovery following neurological injury (Cramer et al., 2011).

Despite these positive impacts, not all effects of neuroplasticity are beneficial. A notable example is the delayed emergence of new-onset epilepsy as a complication of cerebral trauma, which can appear years after the initial insult. This temporal delay suggests that changes in the brain lead to disinhibition and altered neuronal signalling capable of producing seizures (Cramer et al., 2011). Research on transcranial direct current stimulation (tDCS) has further illuminated the complexity of neuroplasticity. When applied to the prefrontal cortex of healthy monkeys, tDCS produced a shift in brain connectivity associated with more efficient learning. In rodents, however, the effect on the right frontal cortex was minimal, while stimulation of the left prefrontal cortex was found to activate fear memory acquisition, likely through deep brain structural changes (Cavaleiro et al., 2020). These findings collectively illustrate that neuroplasticity is a multifaceted function that enables the brain to adapt, but whose effects are highly context-dependent.

Applications of Neuroplasticity in Patients with Neurodegenerative Diseases

Researchers have been examining the significant implications of neuroplasticity for patients with neurodegenerative conditions. Neurodegeneration is characterised by the progressive loss of neuronal structure and function, giving rise to a spectrum of diseases ranging from ALS to Alzheimer's disease (Marzola et al., 2023). At the cellular level, this process involves neuronal damage and cell death, compounded by the role of astrocytes in maintaining antioxidant defences. Disruption of this function contributes to a reduction in white matter volume in the ageing brain alongside neuroinflammation, both of which are associated with age-related cognitive impairment (Marzola et al., 2023).

A separate line of research has emphasised that the role of neuroplasticity in neurodegenerative disease is frequently underestimated. Studies have associated the progression of Alzheimer's disease with both beta-amyloid plaques and tau protein, which forms neurofibrillary tangles that disrupt neuronal communication (Schaefer and Teuchert-Noodt, 2016). Understanding how neuroplastic mechanisms interact with these pathological processes offers a promising avenue for developing interventions that slow or partially compensate for neurodegeneration.

Applications of Neuroplasticity in Patients with Depression, Anxiety, and Substance Abuse

Because neuroplasticity allows the brain to alter its functioning in response to experience, it also provides a mechanism for recovery from maladaptive patterns associated with substance abuse, depression, and anxiety. Overcoming addiction requires the brain to develop and consolidate new cognitive pathways, and Cognitive Behavioral Therapy (CBT) serves as a prominent example of a learning-based therapeutic intervention that explicitly leverages neuroplasticity. CBT can assist individuals in developing adaptive responses to situations in which they would previously have sought substances, and has demonstrated efficacy both as a standalone and adjunctive treatment for drug abuse (Mavrikaki et al., 2019).

The hippocampus is among the most studied brain regions in research on depression. Situated within the limbic system, it plays a central role in emotion, learning, and memory, and contains a high density of stress-related receptors involved in the body's stress response. Synaptic plasticity within the hippocampus is critical to healthy neural development and intercellular communication. However, prolonged stress and anxiety can impair this development, contributing to depression-like behaviors. Specific subregions are particularly vulnerable: CA1, which serves as an output relay for hippocampal signals, can sustain stress-induced damage that results in long-term depression, memory impairment, and learning difficulties, while CA3, which is involved in memory storage, is similarly susceptible to stress-related harm (Mavrikaki et al., 2019).

Neurogenesis in Adults

Neurogenesis refers to the growth and sustained development of new cells within nervous tissue. Researchers have identified high levels of adult neurogenesis in the olfactory regions of the brain, and have established that the brain remains highly sensitive to external stimuli in ways that support growth and development within the hippocampus, fostering an adaptive environment for learning and memory (Gage, 2002). When adult neurogenesis is disrupted or fails, it is associated with the emergence of serious conditions including dementia, major depression, and epilepsy. Stress and other extraneous factors have been shown to inhibit cell proliferation and produce significant

structural changes within the hippocampus (Mirescu and Gould, 2006). Importantly, the same neurogenic effects observed in humans have also been documented in mammalian models, lending cross-species validity to these findings.

Research on learned helplessness paradigms has further nuanced the understanding of stress and neurogenesis. Studies found that a proportion of rats exposed to chronic, uncontrollable stress developed learned helplessness, while others did not. Notably, despite these divergent behavioral outcomes, the effect on adult neurogenesis appeared equivalent across both groups, suggesting a potential dissociation between stress-induced neurogenic suppression and the behavioral emergence of helplessness (Vollmayr et al., 2003). This finding warrants further investigation, as it complicates straightforward accounts of the relationship between neurogenesis and psychological resilience.

Emotional Psychology and Regulation

The study of emotional psychology examines how humans respond to stimuli and the effects those responses have on physical and mental behavior. Emotion can be defined as a reaction pattern through which an individual attempts to engage with a significant event or circumstance (Koole, 2009). Emotions are processed through three interconnected divisions: subjective responses, physiological responses, and behavioral responses. All emotional experience originates in a subjective stimulus, which can elicit a wide range of emotional states depending on the individual. The physiological dimension involves the autonomic nervous system, which is divided into the sympathetic and parasympathetic branches and regulates bodily functions such as heart rate, digestion, perspiration, hormone secretion, and pupil dilation, all independently of conscious control.

The behavioral dimension of emotional response encompasses how individuals express what they feel, through facial expression, body language, vocal tone, and other communicative signals. These behavioral responses serve not only as social communication but also as an important component of individual well-being, as chronic suppression of emotional expression has been negatively correlated with overall health outcomes. The psychology of emotion therefore extends beyond subjective inner experience: it shapes demeanor, physical health, and the quality of interpersonal communication in ways that carry broad significance for clinical and everyday contexts alike (Koole, 2009).

Ethics, Discussion, and Limitations

Several ethical limitations are pertinent to the research discussed in this publication. In any psychological research study, obtaining proper informed consent and providing appropriate disclosure to participants is a fundamental requirement. This is especially complex in neuroplasticity research involving neurodivergent patients, who may face additional challenges in understanding the nature and implications of their participation. Developmental psychologists have also noted that neuroplasticity is most pronounced in younger age groups, meaning that children are frequently subjects of these studies yet cannot independently provide full informed consent, placing a heightened responsibility on institutional review processes and guardians.

A further limitation is the recency of the evidence base. A number of the foundational findings cited in this paper were published in 2009 or earlier, and while they remain scientifically significant, their direct applicability to contemporary empirical and clinical contexts warrants caution. International policies governing neuroscience research are also in ongoing flux, and future investigators will need to attend carefully to cultural and sociological differences when designing and interpreting studies across diverse populations. Techniques commonly used in neuroplasticity research, including deep brain stimulation, transcranial magnetic stimulation, and animal models, raise additional ethical questions regarding risk, welfare, and the limits of extrapolation from non-human to human subjects. Broadening the demographic diversity of study samples, including participants from varied ethnic and socioeconomic backgrounds, will be essential to ensuring that findings are both equitable in their representation and generalisable in their application.

Conclusion

The findings reviewed across this publication collectively illuminate the practical significance of neuroplasticity for understanding and improving brain function. Neuroplasticity has demonstrated a meaningful positive impact on patients with neurodegenerative diseases and on neurologically typical individuals alike. The empirical research into emotional psychology and regulation, the brain's processing of information, and the formation of memory and cognitive learning all carry implications for how individuals respond to their environments and manage their mental health. Neurogenesis research further expands this picture by identifying the mechanisms through which new neural growth can support recovery from cognitive decline and psychiatric illness.

Despite the ethical limitations of some of the studies reviewed, including the reliance on earlier research and the continuously evolving landscape of international neuroscience policy, the body of work presented in this publication provides a meaningful foundation. As methodologies improve, sample sizes grow more diverse, and regulatory frameworks mature, the field of neuroplasticity

research is well positioned to generate increasingly applicable solutions for neurodivergent patient communities and for broader clinical practice.

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