

The Impact of Behavioral Trauma on Decision Making and Neural Function

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Abstract

By examining commonalities across different species, it is evident that there are several similarities in neural mechanisms when it comes to emotional and behavioral traumas that have a long-lasting impact on cognitive abilities through an organization's ability to perceive threats, regulate emotions, and make decisions. Although there has been extensive research into trauma-related disorders, it remains unclear whether trauma-induced changes in decision-making processes and neural pathways are permanent or temporary. In order to tackle the insufficient clarity needed to guide therapeutic approaches and enhance recovery results, this research aims to show that trauma leads to lasting yet not irreversible changes in decision-making processes due to modifications in crucial brain areas associated with emotion, memory, and executive function. Additionally, research involving humans and animals indicates that trauma increases amygdala reactivity, interferes with hippocampal memory functions, and hinders prefrontal cortex management of risk evaluation and behavioral adaptability. Nonetheless, approaches that focus on increasing neural plasticity, such as cognitive therapies or environmental enrichment, can help to improve adaptive decision-making to some extent. This study reveals that trauma is an ever-changing neurobiological process and not actually a fixed experience. Understanding how neural circuits engage with environmental cues will provide important information for clinical risk recovery processes, along with providing insight for developing more effective trauma-informed treatments.

Keywords

Behavioral and Social Sciences, Neuroscience, Behavioral Trauma, Neural Plasticity, Trauma-Induced Decision-Making.

Introduction

There has been a call to address the gap that is crucial to clarify how trauma affects perception, risk evaluation, and behavioral flexibility. Although trauma-related behaviors are often labeled maladaptive, a limited number of studies examine the cognitive and neural components influencing trauma-based decision-making experimentally in both humans and animals. Trauma researchers have described the emotional and clinical (*i.e.*, Post Traumatic Stress Disorder (PTSD) and anxiety) impacts that distressing events can have.

Trauma changes how people react to scenarios in the future. Brain scans show that patients who have experienced trauma have an overactive amygdala, compared to patients without significant trauma. Consequently, they end up jumping at fear and feel emotions more intensely, to the extent that their brain is set to spot danger everywhere, even when nothing is wrong. On top of that, the usual balance from the prefrontal cortex gets thrown off. This implies that it is harder for them to calm themselves down and push past those fear-driven urges.

Trauma throws memory and context out of balance. Some parts of the brain, such as the hippocampus, end up changing their initial function. The hippocampus is the part of the brain that helps sort between present and past events. When the hippocampus shrinks or cannot encode context well, it leads to random outbursts of past events, which clouds the judgment of the patient, making it difficult for affected patients to perform well in society.

Behavioral trauma refers to changes in a person's behaviors and reactions after experiencing a traumatic event. It can lead to behaviors such as avoidance, impulsivity, hypervigilance, social withdrawal, or difficulty making decisions.

Animal research backs this up, showing how trauma shakes up learning and makes it harder for animals to adapt their behavior. For instance, rodents exhibit avoidance behaviors after experiencing stress. They will avoid areas of previously perceived danger, even when there is no longer any threat present. This indicates that rodents have difficulty unlearning their fear-based responses as the behavior persists over time. These findings illustrate conclusively from experiments conducted in strictly controlled settings that trauma influences more than just cognition; it negatively impacts all aspects of behavioral learning and decision-making for animals (including potentially humans), thereby causing them to be stuck in rigid avoidance-based behavioral patterns.

Because trauma is so prevalent and has a significant effect on cognition and behavior, an investigation into how PTSD results in impaired decision-making has not been conducted completely. The body of trauma-related research is extensive; however, there remain substantial gaps between the results obtained from both human clinical studies and animal models. Neuroimaging studies performed on humans provide an unprecedented level of detail regarding the cognitive realities faced by humans who have experienced trauma, and provide an opportunity to explore the subjective complexity of trauma-related fear generalization and resultant decision-making impairments. However, they are constrained by ethical limitations that prevent precise manipulation of neural circuits. In contrast, research on animal models provides opportunities to intervene directly and control mechanisms, but often raises questions about their translational validity to human cognition. The current review integrates evidence across both research modalities in order to identify resulting convergent findings that more accurately reflect authentic, species-conserved neuronal mechanisms as opposed to merely being fragments of research paradigms. This synthesis of cross-species data improves the foundation for understanding trauma's influence on decision-making at the neurobiological level.

A gap that could be explained would be the lack of differentiation between whether trauma stays with a person for the rest of their life. Trauma is currently categorized in a binary system, which does not account for the almost infinite possibilities that could exist, as every person's brain structure slightly varies, as well as their own experiences. Studies state that over time, the brain is able to regenerate parts that were damaged due to trauma, although the specifics of which areas can be regenerated and to what extent are unknown. The present paper changes the viewpoint of trauma from a binary system to an intricate analysis of an individual's brain structure, their own experiences, and their genetics to ensure that proper brain study is being conducted. This framing moves beyond the dichotomy of damage versus recovery and offers a more clinically actionable model of trauma as a neurobiological state.

These insights carry direct implications for the evolution of trauma-informed treatment. Current therapeutic approaches, while evidence-based, are largely designed around population-level symptom profiles rather than individualized neural and cognitive presentations. By identifying the specific neural circuits and processes behind trauma's effects on decision making, this article offers a mechanistic rationale for tailoring interventions to each individual's most prominent cognitive deficits. Also, knowing where neuroplasticity has the greatest potential for recovery provides an underlying rationale for optimizing the timing and sequencing of interventions. Thus, while this research builds upon previously existing knowledge, it also presents a more accurate and mechanistically informative framework that other narrative reviews of the literature do not adequately provide.

Clarifying whether these changes are fixed or modifiable has direct implications for treatment, prevention, and recovery. Through a synthesis of evidence from human and animal studies, this research attempts to bridge the gap between clinical symptomatology, neural mechanisms, and cognitive outcomes to assist in creating enhanced trauma-informed interventions and assisting trauma survivors to achieve improved long-term outcomes.

Methodology

This study's goal is to analyze the differences in emotional and behavioral trauma in their impact on decision-making and the neural mechanisms that cause these changes. This study worked to connect

existing research to propose possible solutions for trauma, such as therapeutic interventions and neuroplasticity.

This study employed a qualitative literature review methodology rather than an experimental or in-field research design. No original data was collected. Instead, findings from previously published peer-reviewed research in neuroscience, psychology, and psychiatry were analyzed and integrated. Academic databases and reputable online sources served as the primary research tools.

Relevant literature was identified through academic databases, including Google Scholar and PubMed, as well as through the journal publisher platforms. Searches were limited to articles published from 1995 to 2025, ensuring that traumatic neurobiological research, which provides foundational studies established through the scientific method, along with current knowledge produced within the field of traumatic neuroscience, was included. The primary keywords that were used to search for this literature are 'trauma,' 'PTSD,' 'decision-making,' 'amygdala,' 'prefrontal cortex,' 'hippocampus,' and 'neuroplasticity,' and have been combined and modified using Boolean operators (AND, OR) to better target articles that include keywords relevant to this review.

Primary sources consisted of peer-reviewed journal articles reporting empirical findings from human neuroimaging studies, longitudinal clinical research, and controlled animal experiments. Secondary sources included scholarly books and systematic reviews that synthesized or contextualized existing findings. Studies were selected based on methodological rigor, clarity of trauma operationalization, sample size adequacy, use of validated neurobiological measures, and relevance to decision-making processes.

The collected literature was analyzed using a thematic approach. Research studies were compared in order to highlight the areas of similarity or consistency as they relate to fear generalization or hypervigilance, impairment of decision-making, and traumatic changes to the brain. The emphasis of this research is to provide similar or convergent findings/types of evidence across species and research methods for the same phenomena.

This study did not involve human or animal participants, physical tools, or even experimental procedures. All data were obtained from publicly available online sources. Because the research consisted solely of a literature review, no ethical approval or formal ethical considerations were required.

Results and Discussion

Understanding Behavioral Trauma

Behavioral trauma is the impact of a traumatic event that occurred in a patient's life, which caused changes in behavior, irrational activity, and awkward brain development and structure. It often leads to a person being unable to respond to the experience, making their ability to conduct everyday tasks such as paying attention, regulating their mood, and coordinating orders difficult. Post-traumatic stress disorder, anxiety disorders, and depression can have similar impacts as trauma, and can sometimes come from trauma due to the irrational changes in behavior and brain structure, due to an event that stresses the brain. An issue with understanding trauma would be that it can come in many ways, shapes, and forms, making it difficult to differentiate between a regular action of a patient and a trauma-induced reaction. Trauma has not always been a deficit, as heightened threat detection, avoidance learning, and rapid emotional response increased the likelihood of survival in dangerous environments for early humans.⁴ Primitive mechanisms highlight the need for the body to defend or repair itself against threats to homeostasis through sensitization. Chronic pain, for example, activates sensitizing signals within the central nervous system, thereby allowing the body to evolve to remember and avoid painful stimuli.⁵

These mechanisms prioritize safety by biasing perception and behavior toward identifying potential threats. But in today's world the same responses can become maladaptive. Trauma survivors may avoid neutral situations, have trouble trusting others, or have intrusive memories and physiological arousal to stimuli that only superficially resemble the original trauma. This overgeneralization limits behavioral flexibility and impairs functioning in everyday life.

Trauma does not affect every patient the same way, and some patients would require different treatments from others. Teicher and Samson (2016) demonstrated that childhood abuse causes changes in limbic and prefrontal circuitry that differ from trauma exposure in adulthood, showing how even the timing of trauma can lead to varying impacts. Longitudinal findings from Belleau *et al.* (2020) show that early amygdala connectivity patterns following trauma predict later PTSD severity, indicating that individual neural differences influence recovery trajectories. Hendriks *et al.* (2018) demonstrated that people with a history of multiple trauma exposures experience more chronic and treatment-resistant PTSD, which also emphasizes the role of previous life experiences in outcome heterogeneity. From this, it can be shown that trauma is not a one-size-fits-all issue, and it requires specialized treatment to improve the lives of patients who have lives that differ massively from each other.

Table 1. Impact of Decision Making. These neural shifts manifest in several specific behavioral patterns that influence daily life.

Decision-Making Impact	Description	Resulting Behavior
Fear Generalization	Responding to safe stimuli as if they were the original threat.	Avoiding crowds, travel, or new relationships.
Hypervigilance	Persistent monitoring for danger that biases risk assessment.	Reducing exploration and avoidance-based choices.
Impaired Cost-Benefit	Prioritizing immediate safety over long-term gains.	Avoiding therapy despite its potential for long-term recovery.
Impulsivity	Seeking immediate relief from emotional distress.	Engaging in risky behaviors to dull psychological pain.

The table demonstrates how trauma can significantly alter decision-making by increasing fear, hypervigilance, and impulsivity while impairing the ability to weigh long-term consequences. These changes can lead individuals to avoid beneficial experiences, prioritize immediate safety or relief, and engage in risky behaviors. The table highlights how trauma can influence everyday behavior and contribute to patterns that may make recovery more difficult.”

The Effects of Trauma on Decision-Making

One major way trauma alters decision-making is through fear generalization, which is the tendency to respond to stimuli resembling a traumatic event as if they pose the same level of threat (Table 1). This process shifts decision-making toward rapid, emotion-driven responses rather than flexible, context-sensitive evaluation. In humans, PTSD is characterized by increased fear responses to trauma-related cues, which reflect a failure to discriminate between dangerous and safe contexts.⁷ Neuroimaging studies suggest that this is due to amygdala hyperactivity, combined with a reduced contribution of the hippocampus to contextual processing.¹ As a result, trauma survivors may make maladaptive decisions, such as avoiding crowds, travel, or relationships, even when these situations pose no real threat. In a longitudinal study involving 529 Dutch firefighters in the Netherlands, it was indicated that fear generalization predicted the severity of PTSD symptoms and other anxiety-related pathologies.⁸ The same study also noted that stimuli related to safety signals predicted PTSD symptoms, while stimuli related to danger signals were associated with neuroticism. This indicates that those who suffer from PTSD and anxiety can benefit from discrimination training to distinguish between safety and danger stimuli.

A second critical effect is considered hypervigilance, which is characterized by persistent monitoring for danger that biases risk assessment. In rodent studies, traumatized animals avoid environments associated with stressors even after threats are removed, demonstrating reduced flexibility and impaired learning.⁹ Humans show similar traits, since hypervigilance promotes avoidance-based decision-making and undermines exploration.¹⁰

Trauma causes a mix of impulsive behavior and extreme fear, which depends on the specific circumstances of how, when, and where they received the trauma. Some patients display signs of extreme impulsiveness, while others display signs of constant paranoia. This duality reflects disrupted regulation by the prefrontal cortex over emotion-driven limbic responses.¹¹

Finally, trauma impairs cost-benefit evaluation, a function strongly associated with the ventromedial prefrontal cortex. Neuroimaging studies show reduced prefrontal cortex activity in trauma survivors, causing patients to make decisions that prioritize immediate safety over long-term benefit, making it difficult to help patients, as their trauma makes them unwilling to undergo remediation.⁷

Neural Changes in the Brain Due to Trauma

The amygdala is responsible for making people feel fear and anger, which can cause them to make irrational decisions. When patients identify a trigger of their trauma, their amygdala enters an excited state, causing the patient to experience extreme behaviors, similar to what patients with PTSD endure.

The hippocampus helps patients remember and understand when and where specific moments of their lives occurred. When a patient experiences trauma, the hippocampus is unable to differentiate between the past and present, causing the hippocampus to show patients flashbacks of their trauma, which can cause a spiral of the amygdala's reaction fueling the hippocampus, and vice versa.

The prefrontal cortex helps patients make decisions and stay rational. Patients with trauma have a weakened prefrontal cortex, which contributes to the irrational behavior. Without the prefrontal cortex to regulate the brain's functions, the amygdala and hippocampus overwhelm the brain, making patients experience severe reactions stemming from their trauma.

Patients unaffected by trauma have a more relaxed amygdala and hippocampus, along with a stronger prefrontal cortex. It is currently unknown why these specific changes occur, and what could be done to reverse these effects without risking damage to other parts of the brain, as the complex nature of the brain makes it difficult for scientists to understand what parts of the amygdala and hippocampus need to be suppressed, and what parts of the prefrontal cortex need to be strengthened to return patients to a state of normalcy.

Theories of Trauma Reversibility

While trauma can leave lasting marks on our brains, there is evidence that our brains can change and adapt through therapy and learning. Exposure therapy, a type of talk therapy, helps patients relive memories in a safe space, slowly reducing fear responses. Studies by Foa *et al.* showed that prolonged exposure therapy greatly reduced PTSD symptoms by helping the brain create connections. Exposure therapy focuses on calming fear, changing thinking patterns, and promoting positive interpretations, leading to broader emotional healing. Another benefit of therapy after trauma is updating memories. Research by Monfils *et al.* has expanded the understanding of memory reconsolidation and opened new possibilities for reversing the effects of trauma. The study found that introducing non-threatening information shortly after a traumatic memory is recalled can disrupt the reconsolidation process, potentially weakening or even erasing aspects of the original traumatic memory. The human brain's ability to form connections provides hope for recovery. Medications like MDMA and ketamine may help our brains change and adapt, allowing for emotional processing during therapy sessions. In addition, non-medication therapies, like mindfulness meditation, aerobic exercise, and neurofeedback, have been shown to strengthen brain areas and reduce activity in areas that process fear.

Implications for Treatment and Future Research

The longer trauma remains in a patient's brain, the more ingrained it becomes with the patient, making it difficult to treat after an extended period of time. Personalized therapy is required in order to treat patients, as each and every patient has their own individualized experiences, which are difficult to categorize. However, patterns could be made between patients to strike at the issue of specific types of trauma to develop systems for dealing with patterns already seen by therapists.

Education and prevention can reduce the societal burden of trauma by promoting resilience, especially in children and adolescents. Future research could involve non-invasive brain stimulation, AI-assisted therapy, and gene-environment interactions.

Limitations

A crucial limitation would be the lack of a systematic review, as articles were chosen by individual researchers. Selection bias could have been at play due to the studies being identified by the researcher's judgment, so faulty judgment could lead to inaccuracies. This also means that findings that aligned more clearly with the central thesis may have been inadvertently weighted more heavily than contradictory or inconclusive evidence. This is particularly relevant given that the neuroimaging and clinical studies synthesized here, such as those examining amygdala and prefrontal function in PTSD, vary considerably in their sample compositions and imaging methodologies. Future reviews addressing the same questions would benefit from preregistered search protocols and formal quality-appraisal frameworks such as PRISMA to reduce this risk.

A second limitation concerns the generalizability of the evidence base. The majority of studies included in this review were conducted in North American and European populations, with research samples drawn predominantly from clinical or military cohorts, such as the Dutch firefighter cohort examined by Lommen *et al.*, and the combat veterans studied by Bremner *et al.*^{3,8} This geographic and demographic concentration limits how broadly the findings can be applied, as trauma prevalence, symptom expression, and treatment access vary substantially across cultural and socioeconomic contexts. As discussed in the body of this review, mental health stigma can influence how trauma is expressed and reported in non-Western contexts, however, culturally situated findings of this type are a minority in the literature reviewed. Caution should be exercised in generalizing the conclusions from this body of evidence to underrepresented populations.

A third limitation arises from the challenge of translating findings across species. Animal models, particularly rodent studies, were central to establishing mechanistic evidence for fear generalization, extinction impairment, and hippocampal dysfunction.⁹ However, the degree to which rodent neural architecture and behavioral repertoire parallel the complexity of human decision-making remains a subject of ongoing debate. Rodent paradigms typically measure avoidance and freezing behaviors as proxies for decision-making, which may not capture the full range of cognitive, emotional, and social factors that influence how human trauma survivors navigate choices in real-world environments.⁹ This translational gap should temper confidence in mechanistic claims derived primarily from animal data, even where findings converge with human neuroimaging evidence.¹⁰

Finally, the temporal scope and heterogeneity of included studies present challenges for drawing unified conclusions. The reviewed literature spans three decades, from Bremner *et al.*'s foundational 1995 hippocampal volume measurements to contemporary clinical research, such as Rothbaum and Watkins's 2025 update on psychotherapy outcomes, during which neuroimaging technologies, diagnostic criteria for PTSD, and therapeutic approaches have evolved considerably.^{3,14} Additionally, the variety in the operationalization of trauma across studies, from single acute events to chronic childhood abuse and neglect, to repeated trauma exposures over a lifetime, makes it difficult to establish consistent cause-and-effect relationships between the type of trauma, neural change and decision-making outcome.^{2,6} This heterogeneity limits the precision of any overarching conclusions about trauma as a unified phenomenon.

Recommendations for Future Research

Future investigation should aim at applying longitudinal, multimodal designs that study neural and cognitive alterations across the entire post-trauma period. The current state of affairs is characterized by cross-sectional approaches that capture a certain moment of functioning but do not allow tracking the evolution of processes. For instance, the longitudinal prospective design used by Belleau *et al.* aimed at assessing amygdala connectivity patterns after acute trauma to predict future severity of PTSD, which can serve as an example of what kind of approach should be expanded. Research that combines neuroimaging with repeated administration of cognitive tests and clinical assessment will help to find out whether the identified neural alterations are acute or become persistent across recovery stages. In

addition, the diversity of populations involved in the studies will contribute to the increase in external validity of results and identification of factors such as timing and culture that influence recovery outcome, based on the developmental insights provided by Teicher and Samson.

In order to control for variables that might confound results from such studies, researchers will want to define reliable neuroplasticity biomarkers. If researchers can determine the characteristics of an individual that would indicate they have a better chance of responding positively to prolonged exposure therapy, pharmacotherapy (e.g., MDMA; ketamine), or even non-invasive methods (e.g., mindfulness; neurofeedback), then the method of treatment can be tailored to the individual, and there will not be a need for trial and error. As research in reconsolidation of traumatic memory conducted by Monfils *et al.* shows, the moment when traumatic memories are reactivated may turn into the best opportunity to intervene individually. Thus, there should be collaboration between computational neuroscience and clinical psychology to apply machine learning to the identification of predictive patterns that can enhance the theory of traumatization and describe mechanisms of recovery.

Conclusion

Behavioral trauma significantly impacts the decision-making process through alterations in the neurobiological circuitry involved in processing fear responses, memory consolidation, and executive functioning. The following literature review focuses on the impact of trauma on behavioral tendencies towards threat detection and survival needs, typically leading to reduced adaptability, logical thinking, and future planning. Behavior associated with trauma includes avoiding dangerous situations, hypervigilance, generalizing fears, impulsive actions, and problems in assessing cost-benefit ratios.

As a summary, the main conclusions resulting from the collected information show that decision-making problems of people who have suffered from some behavioral trauma are due to certain neurobiological abnormalities. Specifically, consistent for humans and animals, neurobiological alterations due to behavioral trauma are increased activity of the amygdala, decreased performance of the hippocampus in recognizing the environment, and failure to involve the prefrontal cortex in regulatory activities. Thus, evaluation problems occur; that is, a person's reaction to stimuli in the present moment can be similar to the one experienced in response to previous threats. However, studies related to the application of exposure therapy and neuroplasticity prove that these changes are not always permanent.

Generally speaking, based on the collected information, it can be argued that behavioral trauma is a temporary neurobiological phenomenon that does not cause any permanent damage. Even though trauma cannot always be avoided, special treatment methods allow treating trauma-related decision-making problems. Furthermore, neuroscience will continue making valuable contributions to developing new trauma-specific treatment techniques.

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