

# A Review of the Neurobiological Mechanisms of Music Therapy and the Relationship to Thanatosonics

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## **Abstract**

The primary concerns of this review are centered around the issue of interfering neuropsychological symptoms of post-traumatic stress disorder (PTSD), along with the ability of personalized, accessible musical tools to confer stability and groundedness toward those suffering from PTSD. The goal is to offer therapeutic tools that can help modulate PTSD's negative effects. Related to this is the phenomena of thanatosis, the idea that traumatic psychosocial experiences can engrain sound-event associations that blur the line between sounds, sensations, and traumatic life experiences. To directly address this concern, it is critical to explore mechanisms of stress management and neural rewiring potential that can alter one's fixated, interfering, and traumatic sound-event associations. This review explores the neurobiological mechanisms of music's potential to serve as a therapeutic tool for those suffering from triggering symptoms of PTSD. We argue that based on prior findings of the benefits of music therapy and the relationship between sound and violence through thanatosonics, the efforts of SoundMind Solutions to create a personalized, accessible music therapy app will fulfill the unmet need of offering a tool that enables self-control emotional modulation of one's responses to triggering stimuli.

## **Introduction and Methods**

To explore the neurological basis behind music therapy's effectiveness and its potential application for those suffering from PTSD, we conducted a comprehensive literature review of neurobiological, psychological, sociocultural, and thanatosonic origins. Integrating these published findings, we worked to construct a unified foundation of knowledge that can serve as a cohesive reference tool to support the SoundMind Solutions effort and the global initiative to serve the needs of those struggling with PTSD or related conditions.

## **Results and Discussion**

### *Historical Context*

For multiple generations and cultures, music has held cultural significance to help facilitate learning in social contexts and establish emotional well-being, offering potential use in therapeutic applications (Trimble & Hesdorffer, 2017). For instance, rhythmic training between motions and music has helped traumatic brain injury (TBI) victims relearn physical motions. Neurologically,

adjusting the musical stimulus to a sensory set of sounds that are emotionally arousing for patients has been shown to affect cerebral and limbic system activity (Trimble & Hesdorffer, 2017).

Following WWI, music therapy began to be put into practice to assist veterans suffering from the physical and emotional trauma of combat (Stegemöller, 2017). Using the ideas of neuroplasticity, the ability for music to alter neurological wirings and associations allows for the possibility of customized musical associations to change individual synapses or entire cortical networks (Stegemöller, 2017). In regard to SoundMind's efforts, this is crucial because utilizing personalized music as a therapy tool can help PTSD victims reassociate triggering stimuli with music they find calming and grounding, helping rewire their cortical networks to respond appropriately to non-threatening stimuli. Cortical rewiring, in turn, could offer explanations and a potential solution behind the interfering psychological symptoms of PTSD and the ability to alter emotional responses to triggering stimuli (Stegemöller, 2017).

### ***Relationship to Thanatosonics***

The promising potential of cortical rewiring to lead to long-lasting behavioral changes is explained by the concept of thanatosonics, the phenomena that the boundary between sound and violence becomes blurred under extreme psychological and social pressures (Daughtry, 2014). As sensory memories become conditioned to be associated with certain traumatic experiences, rather than as the objective or non-threatening source of sound, emotional experiences triggered by certain sounds can come to interfere with routine, everyday life (Daughtry, 2014). To address these interfering symptoms of PTSD, music therapy has the potential to trigger neuroplastic mechanisms to help initiate healing in response to one's traumatic experiences. This is critical because SoundMind Solutions utilizes the proven benefits of music therapy through a phone app to help promote healing, primarily healing of one's mental associations to non-threatening stimuli, for those suffering from traumatic experiences.

### ***Mechanisms behind Successful Intervention***

Prior investigations have noted the neurological mechanisms behind the effectiveness of music therapy. Dopamine is considered a critical compound as the main neurotransmitter of the reward pathway, which includes areas such as the ventral tegmental area (VTA) and nucleus accumbens (NA) (Stegemöller, 2017). This is relevant to our argument because these areas have been considered crucial components of cortical remodeling and long-term potentiation, the neurological mechanisms behind learning, and re-learning certain associations, such as relearning non-threatening associations with sounds currently linked to traumatic experiences (Stegemöller, 2017). In addition, listening to enjoyable music has been shown to activate these neurological reward networks, allowing music to be paired with typically non-music related behaviors, such as reflexive responses to triggering sounds. This supports our argument for the use of music as a therapeutic tool to condition other appropriate behavioral responses (Stegemöller, 2017). A

fundamental principle cited behind this idea is the Hebbian theory, the idea that “neurons that fire together wire together” (Stegemöller, 2017). Thus, pairing musical rhythms with certain physical and physiological activities, such as slowing breathing or heart rate during emotionally arousing situations, can trigger the simultaneous firing of neurons to control certain behaviors, leading to more robust behavioral changes that could offer stable, sustainable lifelong changes for those suffering from PTSD (Stegemöller, 2017).

The VTA and NA have been shown to be activated when attention is focused on music that the listener finds enjoyable (Stegemöller, 2017). In conjunction with these centers, dopamine is released from the brain’s mesolimbic reward centers in anticipation of experiencing these enjoyable peak emotions from music. Serotonin has also been associated with feelings of satisfaction from expected outcomes and is elevated when listening to pleasing music, suggesting an association and therapeutic potential of music based upon neurobiological mechanisms (Altenmüller & Schlaug, 2015). This supports SoundMind’s connection between music and feelings of satisfaction and stability, supporting the argument that music therapy is a crucial and effective tool for healing from PTSD -- a tool SoundMind is working to make accessible and a reality for those in need.

Dopaminergic neurons have been shown to regulate autonomic and physiological responses to emotionally arousing stimuli in the mesolimbic reward system. Music, additionally, has been cited as increasing cerebral blood flow to brain areas associated with reward and reinforcement of pleasurable behaviors (Landis-Shack, Heinz, & Bonn-Miller, 2017). Thus, by pairing one’s music of choice with an experience conceptualized as enjoyable, reward networks may be reactivated to help reinforce the learning of non-music related behaviors, such as emotional responses to certain sounds or sensory triggers. This is crucial for SoundMind’s mission -- because musical learning can activate dopaminergic neurons, it offers a powerful tool for altering and cultivating attention and learning, two factors PTSD victims often struggle to control (Altenmüller & Schlaug, 2015).

Previous studies have also noted the emotional brain areas -- those areas associated with the perception, interpretation, and memory of emotion – as the inner surfaces of the frontal lobes, cingulate gyrus, hippocampus, amygdala, and midbrain, areas that thus become crucial in the emotional perception of music. Specifically, the parietal and temporal-occipital brain regions have been shown to hold strong roles in acquiring music skills as well as expressing emotions (Altenmüller & Schlaug, 2015). Thus, there is a clear neurobiological connection between brain areas activated by music and involved in emotional perception, justifying music as a prime candidate for intervention tools that can help modulate emotional responses.

Additionally, music affects multi-sensory and motor integration areas, allowing inputs from auditory, visual, and somatosensory regions to be associated and re-associated with one another through musical relationships (Altenmüller & Schlaug, 2015). Molecular- and cellular-level

neuroplastic changes may include an increase in gray matter density (due to enlarged neurons, a change in synapse density, increased neuronal support structures such as glial cells, and reduced apoptosis rates), increased white matter density (increased myelination and thus increased neuronal signal transmission rates), and enlarged blood vessels and capillaries necessary to support neural networks (Altenmüller & Schlaug, 2015). Due to the molecular- and cellular-level changes also associated with macro-level changes, such as physical movement and behavior, music offers a promising therapeutic tool based upon its core mechanism of affecting changes on a neurological level, creating a long-lasting ability to maintain beneficial behavioral changes initiated by SoundMind's music therapy approach.

### ***Personalized, Targeted Music Therapy and its Unique Advantage***

A distinction should be made between the effectiveness of music and nonsensical sound that lacks intention or personal meaning. Noise has been shown to incur negative impacts on neuroplasticity, causing stress and impairments to cognition and memory. Music, however, may promote neuroplasticity, as evidenced by the ability of music therapy to promote psychosocial abilities (cognition, attention, memory, social skills) in TBI patients (Stegemöller, 2017). Music has also been correlated with self-esteem and reduced feelings of worthlessness, thus enhancing resilience, the ability to regain control of one's life, and the sensation of community connectedness. Additional studies have shown music to improve self-esteem and awareness of the environment and self, as well as to modulate anxiety, stress (such as lowering stress hormone cortisol levels), mood, and promotion of feelings of self-control in patients with mental disorders (Novotney, 2013; Stegemöller, 2017). Music also increases the release of endorphins (natural painkillers), oxytocin, and endogenous opioids (stress and pain-reducing hormones) (Landis-Shack, Heinz, & Bonn-Miller, 2017). Because of this, music therapy can affect the individual on cognitive, biological, and emotional levels, offering an effective therapeutic intervention tool as initiated by SoundMind's efforts.

### ***Conclusion***

With the current knowledge base and the understanding that the needs of those struggling with PTSD or related conditions have yet to be sufficiently fulfilled, we hope that this review will offer a sound foundation and base from which to grow our knowledge, investment, and therapy development for this effort. With the goal of SoundMind to be to develop an accessible, personalized tool that helps manage stress and trigger responses for those suffering from PTSD, we hope and anticipate that SoundMind Solutions will continue building off of this current integrated knowledge base to grow the tools and therapy efforts that support those with PTSD.

## **References**

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