

The Use of Music Therapy as an Alternative or Supplementary Form of Treatment for Mental Health Conditions

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I. Brief Description

Have you ever had an experience when you were having a really bad day and when you listened to music, it improved your mood? Have you ever wondered if there was an actual scientific explanation on why this happens? Can this help our moods or feelings? This project aims to answer these questions and find out if this can be a revolutionary discovery for future methods of therapy.

Music therapists use a person's responses and connections to music to encourage positive changes in mood and general mental mindset. Music therapy can include listening to music or creating music with instruments of all types. It may also involve singing or moving to music. It is an alternative to other types of therapy, such as counseling or cognitive behavioral therapy (CBT) (Zoppi, 2020).

II. Science Concepts Involved

A. Biology

A lot of synthetic drugs used in the treatment of mental health illnesses have side-effects, which led researchers to look for alternative therapies with no side effects. Research on music therapy suggests that it can produce positive results on the mental wellbeing of patients.

Dopamine levels rise when people listen to music. The "motivation molecule" of the brain, dopamine is a crucial component of the pleasure-reward system. The same brain chemical also causes orgasms, the runner's high, and the feel-good moods brought on by eating chocolate. According to Bearman (2018), music has been found to stimulate the synthesis and release of oxytocin; a major 'feel-good' neuropeptide.

Dopamine, a neurotransmitter that makes you feel happy, is released with music entering our brains. Music increases dopamine in the nucleus accumbens, the part of the brain that seeks pleasure and reward. Dopamine is also increased by music in the putamen, the part of the brain that regulates body movement and coordination. This is why rhythmic music is used to stop the symptoms of Parkinson's disease but only temporarily.

When the music goes off, the shaking, stiffness, and difficulty with balance and coordination come back. Adrenaline level is increased by loud and rhythmic music. It keeps you awake during a long and boring drive. Music activates the part of the brain that processes and triggers emotions, the amygdala. Music can control fear or make you ready to fight. Amygdala is activated when you feel shivers go down your spine. Classical music such as Mozart reduces heart rate and blood pressure. Relaxing music reduces the amount of the "vigilance chemical" noradrenaline in our system which makes us fall asleep. Music also increases neurogenesis in the hippocampus, allowing the production of new neurons and improving memory.

Alzheimer's disease is a brain disorder that slowly destroys memory and thinking skills and, eventually, the ability to carry out the simplest tasks (What Is Alzheimer's Disease?, n.d.). Music may help reduce agitation and improve behavioral issues in patients with Alzheimer's, and it helps patients connect with their loved ones, as music memory often remains longer than others. Alzheimer's disease typically starts in the areas of the brain responsible for memory and ends in the brainstem which controls our heart rate and breathing. Music memory remains intact until the late stages of Alzheimer's before the disease targets the brainstem (Northwestern Medicine, 2020).

B. Chemistry

As shown in Figure 1, dopamine (C₈H₁₁NO₂) is made through a process of biosynthesis (a complex production of chemical compounds made by living organisms) in the body, mainly by nervous tissue and the medulla of the adrenal glands. First going through an oxidation reaction (hydroxylation) of the amino acid L-tyrosine to L-DOPA via the enzyme tyrosine hydroxylase, also known as tyrosine hydroxylase, and then by the decarboxylation of L-DOPA by aromatic L-amino acid decarboxylase (World Of Chemicals, n.d.). The enzyme dopamine β-hydroxylase absorbs dopamine into vesicles and converts it to norepinephrine. The enzyme phenylethanolamine N-methyltransferase converts norepinephrine to epinephrine in the adrenal medulla and a few specific areas of the brain (Aminoff & Daroff, 2003).

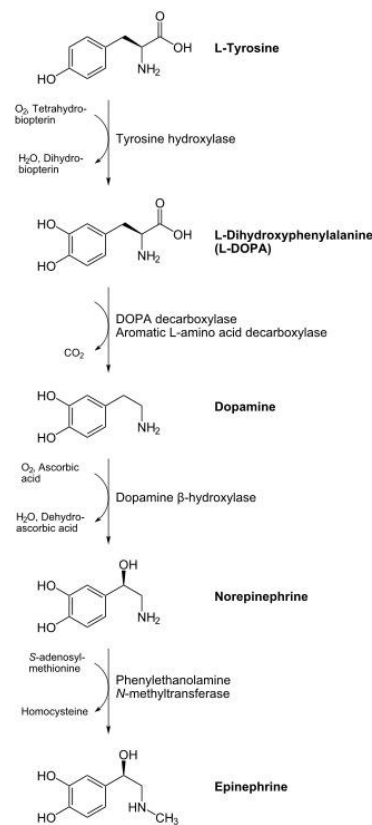


Figure 1. [Figure, Biosynthesis of catecholamines adrenaline (epinephrine). . .]

According to UPMC (2017), listening to music you like may cause your brain to generate more norepinephrine and melatonin, two chemicals that are associated with pleasure. It might also lessen the body's synthesis of stress-inducing hormones. Consequently, music therapy has the potential to: reduce tension/reduce anxiety, enhance sleep, reduce your depression, encourage a good mood, increase your confidence, and boost your energy.

The adrenal medulla produces norepinephrine ($C_8H_{11}NO_3$), a stress hormone that is released into the circulation and serves as a neurotransmitter in the central nervous system. It has an impact on the brain regions in charge of regulating attention and movement. It can raise the heart rate, release glucose from energy reserves, and boost blood flow to skeletal muscle. It is also related to the fight-or-flight reaction (News Medical Sciences, 2019). Norepinephrine works by attaching α - and β -adrenergic receptors, often known as adrenoceptors because of how they respond to adrenal

hormones in various organs. Due to norepinephrine being an adrenal hormone, its release will trigger vasoconstriction, which increases blood pressure (American Chemical Society, 2020).

Serotonin levels in the blood also rise as a result of listening to music. Serotonin (C₁₀H₁₂N₂O) is a fundamental amino compound that is the 5-hydroxy derivative of tryptamine. It functions as a neurotransmitter, a mouse metabolite, and a human metabolite. It belongs to the family of phenols, hydroxy indoles, tryptamines, phenols, primary amino compounds, and monoamine molecular messengers. Serotonin modulates various critical physiological activities including neurotransmission, gastric motility, hemostasis, and cardiovascular integrity. This biochemical mediator's widespread physiological actions and distribution are explained by a number of receptor families (RECEPTORS, SEROTONIN) (PubChem, n.d.). It is a key function that influences comprehension, mood, and memory. Figure 2 shows the chemical structure of serotonin.

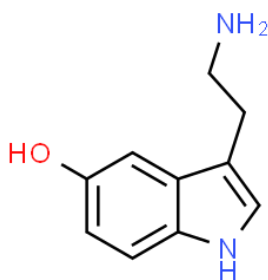


Figure 2. *Chemical structure of serotonin.*

Music therapy also increases oxytocin levels in the body. With the amino acid sequence CYIQNCPLG, oxytocin (C₄₃H₆₆N₁₂O₁₂S₂), also known as the “love hormone” or “cuddle chemical”, is a cyclic nonapeptide hormone that also functions as a neurotransmitter in the brain. Additionally, oxytocin stimulates the G-protein coupled receptor signal transduction cascade, which results in elevated intracellular calcium concentrations, by binding to oxytocin receptors in the uterine myometrium. The contractile protein actomyosin is induced by elevated calcium concentration levels via activating myosin light chain kinase. This encourages contractions of the uterine smooth muscle (PubChem, n.d.). Figure 3 shows the chemical structure of oxytocin.

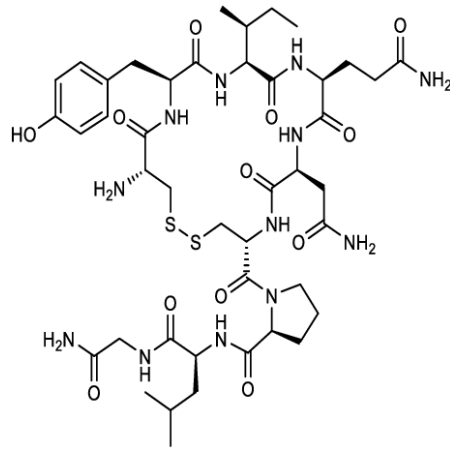


Figure 3. *Chemical structure of oxytocin.*

C. Physics

Sound is a form of energy that is produced by the vibration of an object. These vibrations create pressure waves, which propagate through a medium such as air or water. The study of these pressure waves is known as the physics of sound. Sound waves are classified as longitudinal waves, which means that they travel in the same direction as the wave is moving.

When we talk about music therapy, it's important to understand the physics of sound waves. According to a study by R. Wigram, specific sound frequencies and patterns can be used to stimulate the brain and promote relaxation, reduce anxiety, and improve mood (Wigram, 2004). Sound waves consist of regions of high and low pressure known as compressions and rarefactions, respectively. In music therapy, slow, soothing music with a low frequency and amplitude can have a calming effect on the body and mind, whereas fast-paced, upbeat music with a high frequency and amplitude can promote energy and arousal (Koelsch, 2014).

Moreover, the resonance and vibrations produced by certain instruments, such as drums or Tibetan singing bowls, can create a therapeutic effect on the body. These instruments produce sound waves with a specific frequency and amplitude that can

resonate with different parts of the body, creating a physical vibration that can lead to a feeling of relaxation and release (Wigram, 2004).

The use of music therapy as an alternative or supplementary form of treatment for mental health conditions is rooted in the physics of sound waves and their ability to stimulate the brain and promote physical and emotional relaxation.

III. How to Use the Output

Music therapy is a highly personalized type of therapy. There is a great deal of customization and specification involved. In its formal forms of therapy, it requires getting in touch with a licensed therapist who can choose the course of treatment that is best for a person. In contrast, informal types of therapy can involve casually enjoying music, singing along, playing instruments, and dancing. Music therapy is a generally established idea in research due to its versatility and efficacy, and some of its advantages and applications are listed below:

- It eases pain. In individuals with chronic pain disorders, music therapy has been shown to lessen pain intensity and enhance pain management (Lai et al., 2021).
- It reduces depression and anxiety. Numerous individuals, including cancer patients, people with chronic pain, and people who have mental health disorders including depression and anxiety, have found this type of therapy to be successful in lowering the symptoms (Yang et al., 2021).
- It boosts motor function. The balance and walking of people with Parkinson's disease and other mobility abnormalities have been proven to be improved by it (Brockett et al., 2021).
- It enhances cognitive abilities. According to research, music therapy helps people with dementia perform more cognitively, those with Alzheimer's disease experience fewer behavioral symptoms, and people with other neurological illnesses benefit from it as well (Zeng et al., 2020).
- It improves social abilities. It has been demonstrated that the therapy helps children that have autism spectrum disorder (ASD) and other developmental difficulties to strengthen their social skills (Brownell et al., 2020).
- In relation to the concepts above, music therapy also helps alleviate stress, lessen blood pressure, and enhance memory.

To conclude, music is an everyday concept that has a significant presence in every person's life. It is widely utilized and can be used clinically to treat patients through music therapy. Music therapy has a variety of advantages that are connected to

the biology, chemistry, and physics that underlie it, making it a highly valuable scientific advancement.

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