RESEARCH ARTICLES

Neural and Psychological Mechanisms of Dance Movement Therapy Efficacy

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Dance movement therapy (DMT) is a dance and movement-based therapy that relies on non-verbal communication. It is a novel approach that has gained increasing attention in treating psychological disorders. Stress is one of the components that is involved with most psychological disorders in modern society, and one potential treatment for psychological disorders is DMT. DMT has demonstrated influence in providing mental relief to patients with cancer and for mild stress. Though DMT is largely developed based on the empirical outcomes of DMT practice with patients and individuals, researchers have been conducting brain imaging and neuroscience research on exercises and professional dancers. This research on stress has also established a potential brain mechanism for DMT. Therefore, looking into this brain mechanism could yield an explanation for its effectiveness in stress relief. This review investigates how DMT contributes to stress relief (i.e., through mirror neurons and the activation of motor regions, which stabilizes an individual's cortisol levels thereby restoring homeostasis). DMT in its essence is an exercise, and the music accompaniment contributes to its effectiveness. Group practice of DMT is common, which can magnify the function of mirror neurons by conveying feelings to an individual through altering their physical movement. DMT tackles stress by drawing from all these fields. The variety of DMT types and the hybrid process combining movement and music contributes to the complex effects on practitioners. Future research to support DMT can help clarify and improve evidence for its efficacy and encourage participation.

Introduction

Dance movement therapy (DMT) as a newer therapy method has become prevalent recently and has gained more empirical support compared to last century. It is also suggested to be a potential method to treat mood disorders (Pessoa et al., 2019). Due to the complicated mechanism between the wide range of mood disorders, this review specifically focuses on how DMT is related to the stress level. The stimulation in the brain region, both directly to the motor region or the indirect involvement of arousal and effective brain region, through dance movement therapy is thought to reduce stress.

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However, the links between DMT, stress reduction, brain activation, and mood disorders are not fully understood. This review will evaluate these links.

The wide application of DMT in psychiatric and clinical circumstances has facilitated the development of research. It has the most research on the application in psychological disorders and the autism population, as well as a few reviews focusing on its influence in diseases such as breast cancer (Millman et al., 2021). This focus on nonverbal communication during the treatment often establishes a contrast with counseling-based therapy when treating mood disorders (Millman et al., 2021).

The goal for this literature review was to characterize the brain mechanism behind DMT to support its application in daily life. This review aims to encourage the development of DMT and to promote a low-cost and safe way of releasing stress. The potentially wide application of DMT extends to a larger group of individuals who suffer chronic stress under heavy workload, and to teenagers who suffer from a variety of stress (Zhao & Peng, 2020). Therefore, the prospects of DMT development are worth paying attention to. This review will include DMT from multiple world regions since the cultural background and the topic has a low correlation.

While the above applications focus on individual body movement, DMT often is conducted in groups with a professional who leads the session (Millman et al., 2021). Though an individual session is more favorable for specific clinical conditions and to achieve significant results (Payne, 1992). The substantial types of DMT developed from the same root have explored possibilities in multiple fields. In 1992, Payne edited *Dance movement therapy: theory and practice* that incorporates eleven different DMT subjects for distinct groups different from age, gender, clinical diagnosis and social role. Currently, the clinical application of DMT differs from the diverse types of DMT depending on the patient practicing it (Millman et al., 2021). Across the variations of DMT, the clinical application aims to target a shared biological process centering on stress.

Stress is defined by Hans Selye as a specific biological and physical response to stimuli which does not have a specific association to certain behaviors (James et al., 2023). Stress is a response system that could be triggered by a range of stimuli. Stress is further categorized into distress and eustress, with the former referring to overwhelming and negative effects on the human body and the latter the good and positive ones. These psychological and physiological stress responses are promising mechanisms to explain the benefits of DMT.

In this review, related research regarding stress, DMT, dancer brain fMRI imaging, and exercise was gathered to establish correlation and connection. Literature between the 1970s was excluded for DMT, while literature before the 2000s was excluded for other sections to ensure focus on the newest research. The age group and gender difference for stress and DMT research are not the research's focus, so not specifically discussed.

Stress and the Brain

Stress occurs when homeostasis is constantly under threat or defined as a response to stimuli (James et al., 2023). This suggests that stress could have both positive and negative influence on our lives. Stress is a tool to ensure the survival of our ancestors (Hanson & Hanson, 2020). Our ancestors relied on stress to stay alert, staying in the 'fight-or-flight' mode, to avoid fatal danger in early times of human evolution. However, prolonged exposure to stress, meaning that the stress lingers for a long time instead of resolving as danger diminishes, brings harm to mental health (James et al., 2023). The exposure to excessive long-term stress led to decreased tolerability of it, causing harmful consequences.

The HPA axis plays a significant role in the stress response system (James et al., 2023). In response to stress, the corticotropin-releasing hormone (CRH) from the hypothalamic paraventricular nucleus is released. It also activates the HPA axis (Gjerstad et al., 2018). The CRH then enters the portal vessel to stimulate anterior pituitary creation of adrenocorticotropic hormone. The hormones are then released into blood circulation and reach the adrenal cortex to stimulate zona fasciculata (James et al., 2023). At zona fasciculata, the glucocorticoids, specifically the cortisol, are produced (Gjerstad et al., 2018; James et al., 2023). In other words, the HPA axis is responsible for the regulation of the cortisolcirculating level (Gjerstad et al., 2018). Cortisol is produced in response to stress to regain homeostasis through increasing its concentration as the production continues under HPA axis stimulation.

Cortisol follows a rhythmic cycle called cortisol awakening response (CAR) in humans and primates (Gjerstad et al., 2018). CAR concentration achieves its climax in the early morning and decreases gradually to its lowest concentration around midnight. CAR categorizes under the HPA-axis regulation, and the release of additional cortisol due to the stress stimulus is another way to explain the physiological and neuroscience mechanism behind stress.

LC-NE system is a separate system that works closely with the HPA axis in response to stress (Ross & Van Bockstaele, 2021). The long-term stress alters the LC-mediated response, which increases NE in LC (Morris et al., 2020). As a result, the HPA axis regulation of cortisol is reduced, leading to a high cortisol concentration. The positive association between the LC-NE system and the HPA axis system is essential when observing the stress responses in an individual.

Dance Movement Therapy

DMT has only become popular starting in 1940, due to its comparative novelty to music therapy and counseling-based psychological therapy (Dunphy et al., 2021). Records from the last centuries have documented different kinds of DMT and these have developed into the established major offered in higher education today (Payne, 1992). The pioneers of DMT, such as Marian Chance, were mainly located in the United States. However,

since the 1940s, professional DMT has spread around the world (Dunphy et al., 2021) and will continue to expand its influence. This will be discussed in detail in this section. Neuroscience research on DMT and professional dancers was included and specified (1) the definition of DMT and an overview of DMT and (2) different types of DMT. Any related research on professional dancers or movement and the brain will be included in the next section.

Dance movement therapy (DMT)

DMT focuses on connecting an individual's mind with their movement and utilizing the metaphorical movement to aid the patient's performance in life (Zhao & Peng, 2020). Though DMT is a novel approach in psychological therapy and rehabilitation, dance serves as a communication tool is a behavior that could trace back to the early era of human existence. People practiced dance as a ritual and as a nonverbal communication tool back in time. They were usually performed to show respect to nature (Clément, 2017). The traditional haka dances of the Māori people were established to communicate with nature. There also exists dance for seeking partners, for raising the morale for fights and more. Dance movements are thought to be closely associated with the inner voice of an individual, developing from humans' natural intuition (Zhao & Peng, 2020). Rapid and repetitive life of modern day largely suppresses the creativity and freedom within individuals, which is thought to be against the nature of human beings. Based on this ideal, DMT encourages the patient to find the freedom in mind, spirit and body through the process of dancing. DMT also emphasizes on extending movement to activate muscles that are rarely being used to guide the mind of an individual and to help them feel themselves thoroughly.

The current application of DMT ranges from severe diseases such as cancer, to disabilities such as learning deficiency, and extending to the more generalized social techniques such as tackling colleague relationships (Ho et al., 2016; Zhao & Peng, 2020). From the wide range of applications, stress is often mentioned in the research as a standard to evaluate the effectiveness of the DMT.

Current neuroscience research in DMT includes (1) mirror neuron and nonverbal communication through group DMT (Millman et al., 2021) and (2) the auditory cortices and the music accompanying the dance (Vander Elst et al., 2023). Both aspects tie into the brain mechanism behind DMT.

Types of DMT

The foundation for modern DMT in the United States is laid by Marian Chance. She entered the DMT field because she has a lot of non-professional students who improved their social relationship and gained relief by attending her creative dance classes. She emphasizes the expression of emotions through movement, which leads to an unintentional effect of stress relief. She became

popular in this field and got invited to the hospital, where she utilizes the early stage DMT to help soldiers from WWII to recover from posttraumatic stress disorder (PTSD).

In addition, Isadora Duncan's ideal of a dancer should dance in the way they prefer to obtain freedom from physically and mentally also influences how DMT develops (Zhao & Peng, 2020). Just as dance encompasses a variety of styles featured in different techniques, DMT, which acquired quite some inspiration from the different styles, branches into various types of treatment to fit differently into the contexts. DMTs are often discussed based on different categorizations of groups. Age and diagnoses are two main specifications when designing DMT. More generalized DMT approaches exist as well.

Teenagers and elders are the age groups that have specific design due to certain issues limited to their age. Examples include school violence happening mainly to teenagers and a concern over mental and physical health for elders (James et al., 2023; Payne, 1992; Pessoa et al., 2019; Zhao & Peng, 2020). Children as a group rarely participated individually in a DMT session. A few records on children-mother groups exist to address children-mother interaction both in the United States and the United Kingdom (Meekums, 1991).

Diagnoses often alternate the types of DMT applied as well. In 1947, WWII soldiers who had PTSD, underwent Marian Chase's customized DMT in the hospital (Dunphy et al., 2021). Through mirroring soldier's non-verbal and verbal communication, Marian Chase aims to convey empathy. This led to the idea of kinesthetic empathy, which establishes connection and increases synchronization through mirroring the movement of another individual. Jeannette MacDonald's DMT focused on patients with learning difficulties and put emphasis on individuals. She spent the first session getting to know her patient and building a good relationship before she proceeded to DMT (Payne, 1992). DMT also relieves symptoms of diseases such as cancer. Research was conducted in China among a group of patients with breast cancer who were undergoing radiotherapy. The patients in the study experienced a short-term DMT that was adapted by professionals to fit the group needs (Ho et al., 2016). The research suggested that being able to communicate rhythmically in groups during DMT to other patients who also undergo the radiotherapy may contribute to a significant decrease in stress after the DMT trial.

Neuron, music, and movement and the brain

The research on DMT and the brain remains limited, leaving the brain mechanism behind DMT as an area to explore. The research about dance and brain, and sport and brain aid in understanding the potential mechanism behind DMT. The dance and brain association will focus more on activation of brain regions while the sports and exercises and brain will be more directly

connected to its role in releasing stress. The current research will be presented through (1) mirror neurons, (2) auditory cortices, and (3) professional dancer and exercise neuroscience research.

Mirror neuron and non-verbal communication

Dance and brain research largely relies on the idea of the mirror neuron system. The system involves the premotor and parietal cortices, and supplemented by motor area superior temporal sulcus, and primary motor cortex (Karpati et al., 2015). The use of the motor cortex in the brain during this process introduces the idea of motor imagery, which is defined as simulating the movement by activating the same motor area in the brain corresponding to the movement without physically demonstrating the movement using one's body (Hanakawa et al., 2003).

Mirror neurons and non-verbal communication are closely knitted together to provide a potential explanation of how DMT works (Zhao & Peng, 2020). Mirror neurons are essential to primate because it enables humans to understand each other's movement (Rizzolatti & Craighero, 2004). In practice, perceiving information through other's movements accurately and imitating them is quite necessary for survival. This process is enabled by the mirror neurons in the brain (Zhao & Peng, 2020).

The mirror neurons were originally found in the monkey's premotor cortex. During the experiment, scientists observed the monkey to release spikes both when they did the movement and when they saw the other monkey doing the same movement (Rizzolatti & Craighero, 2004). This finding is linked to imitation, which contributes to social skills such as understanding others' intention and desire (Iacoboni & Dapretto, 2006). Therefore, the patients should be able to convey their emotions through movement to the receiver (either therapist or other member in the group therapy). Vice versa, emotions could be brought to the patients as they do certain movements.

Auditory cortices and music

For dancers, the auditory stimulus precedes the movement stimulus, meaning they tend to receive the sounds cues prior to moving and they dance along with the music (Vander Elst et al., 2023). In DMT the choice of music needs to be chosen with care to achieve certain results subject to the individuals' needs (Payne, 1992). Music is essential to human life (Malloch & Trevarthen, 2018), and it is also naturally intertwined with DMT (Dieterich-Hartwell et al., 2022). The auditory cortices therefore are active throughout the DMT because of the music input.

The rhythm and the syncopation in the music are the two main elements associated with the movement of an individual (Vander Elst et al., 2023). The beat pattern within the music induces a dancer's movement that corresponds to the music. This research is conducted on professional dancers to understand the neuroscience aspect of dance, and therefore serves as a reference but not direct evidence to support conclusions regarding DMT.

Music induces movement also has a potential in inducing synchrony (Bigand et al., 2024). The research on social synchrony is conducted among a group of people participating in a "silent disco", in which everyone is wearing earphones to access the music instead of music being played out loud. Social synchrony is assumed to be achieved through listening to the same music or looking at each other's movement. The research identified more movements that are music-driven compared to partner-driven (visual) or by both factors.

In music-based therapy such as the Bonny Method of Guided Imagery and Music (BMGIM), classical music has the function of inducing feelings from the body and encouraging the expression of those feelings (Abbott, 2005). Other elements such as lyrics, tempo, genre all influence patients in different ways according to the survey sent to the professional DMT therapist in the research by (Dieterich-Hartwell et al., 2022). The therapist often chooses the corresponding music according to their patient group, such as playing nursery rhymes to children to catch their focus.

Professional dancer and exercise neuroscience research

Functional magnetic resonance imaging (fMRI) is used in reviews (Burzynska et al., 2017; Karpati et al., 2015) to analyze an individual's brain activity when they are exposed to the recordings of dance. In the review, research addresses both professional dancers and individuals without dance experience. For professional dancers, the fMRI shows that the brain region that is responsible for observation and imagination presents association with the experience and the ability a dancer has regarding the types of dances played in the video (Cross et al., 2006). Research (Calvo-Merino et al., 2005) suggested that the familiarity of an individual to the video they are perceiving, for example a tango dancer to a tango video, has more intense premotor cortex activity than those who does not have tango experience. The research addressing dance, and the brain largely relies on comparison between professional dancer and non-dancer through fMRI and other brain scanning approaches (Calvo-Merino et al., 2005; Cross et al., 2006; Karpati et al., 2015).

Physical exercises have an association with regular CAR mentioned in the previous section on stress (Vreeburg et al., 2009). A regulated CAR is a sign of homeostasis. Physical exercises have shown a positive association in restoring the abnormal CAR into a healthy CAR for Individuals with depressed mood. In these ways, DMT may have effects on the brain and body's physiology.

Discussion

DMT as a therapy could be applied among patients with severe diseases and individuals who attend dance class in their spare time. One of the factors that is common within all groups of people who undergo DMT is stress—a feeling that could cause detrimental effects or positive influence. Stress has a comparably clearer mechanism that involves brain regions and adrenal gland. Understanding DMT's association with the brain and the body from a

biological direction could draw some potential explanation about how DMT aids the individual in releasing stress. DMT as a therapy could (1) bring patients to face and feel the stress and (2) tackle the stress through exercise. The involvement of music, and the combination of the two aspects formulate a potential explanation of how DMT reduces stress level.

Facing and feeling the stress

Before fixing an issue, one needs to accept that the issue exists, meaning that an individual needs to feel the stress and to understand the body state under stress (Zhao & Peng, 2020). The former demonstrates the mental stage, and the latter focuses on the physical response that would normally be neglected. The ideologies behind DMT are connecting mind and body and seeking freedom through movement. The focus on movement and body are the essential aspects of DMT. It is thought that through feeling the parts of the body that are rarely being used, the patients could achieve a better relationship and familiarity with their body.

DMT often achieves the goal with its metaphoric feature. By simulating certain movements, mirroring members within the group, moving with music that conveys specific meaning, the therapy allows the participants to experience certain emotions and feelings without experiencing the situation. Through connecting the body to the mind by linking emotions to specific movement, individuals would gain more control over their body. This increases their ability to remain stable under the once-through stressful circumstances.

Different movements and positions convey meaning and emotions. This is the representation of the mirror neuron systems in the primates and brain, and they explain how DMT could bring individuals to face and feel stress. A potential explanation for DMT's mechanism in resolving stress is through simulating the movement corresponding to positive emotions to replace the stress with the desirable feelings or achieving homeostasis or peace. This is a spontaneous and intentional act to lower and slow down the cortisol concentration, ultimately leading to a decrease in stress.

DMT as an exercise

DMT is a light physical exercise. The fundamentals of dance suggest DMT to be a therapy that involves movement of certain body parts, and potentially involving the whole body. Dancing in DMT does not compare to professional dancers. The non-professional dance practice mainly features in movement that could be done without a standard in flexibility, strength, and coordination. Physical exercise has proved to have a positive association in decreasing the cortisol level (Vreeburg et al., 2009) through motor imagery. An essential aspect of DMT's effectiveness in decreasing stress level may come from its exercise nature.

Music involvement

Music is essential and helpful for DMT in practice. Music as an input could induce dance movement from the patients, which may also lead to synchrony when individuals perceive a similar feeling to the music or draw by the same beat and syncopation. This is very important for DMT, as it is largely relying on non-verbal communication. The auditory stimulus could also bring certain emotions and feelings which facilitate the execution of DMT.

DMT was not developed based on empirical data and was found by "accident" with the positive response of a student who was taking Marian Chance's creative dance class. Dance is a highly subjective movement that is said to be a natal ability. Even the later professionalized dance styles such as ballet and tango vary from dancers to dancers. All these factors explain the heavy reliance on psychology and cognitive science when implementing DMT. However, the increasing research on dancers and their neural activity and the increasing neuroscience research in the artistic field might open a new perspective to support DMT with empirical evidence, thus opening the door to more possibilities in DMT implementation.

Conclusion

DMT relieves stress through the involvement of the mirror neuron system and the auditory cortisol. The mirror neuron system may support how non-verbal communication works throughout the course of DMT and how the mind and body are associated. The auditory cortisol explains the music involvement in DMT and highlights the integration of music in helping induce movement and emotions during DMT. DMT is also associated with motor imagery that plays into the mirror neuron systems and decreases the cortisol level to restore homeostasis from stressful physiological stages. Featuring in non-verbal and verbal communication to elicit the expression from the patient through dance and movement, the wide application of DMT ranges from psychological relief in diseases such as cancer to conventional problem such dealing with collogues relationship. DMT reduces stress level through influencing mental and physical aspects to lower the cortisol concentration. A combination of identifying and accepting stress, exercising through the body movement and the music accompaniment all contribute to the reduction of stress. All three factors have a proper microscopic level explanation, but more research in brain and dance/art media may lead to a better understanding and wider application.

Due to the focus on how DMT reduces stress, this review neglects the cultural difference that is quite significant in the DMT field. The age difference among stress stimuli is also being left out due to no specific DMT subject of each age group or specifically for stress release. This review attempts to explain the potential neuroscience involvement such as the mirror neuron, premotor cortex brain area, and auditory cortices within DMT to

emphasize on the prospect of DMT application to not only patients but people who feel mild stress on a daily basis. The review aims to provide an unharmful alternative to relieve stress.

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