Music as a Reward: Implications for Music Therapy in Treating Major Depressive Disorder

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ABSTRACT: Music has the power to elicit intense feelings of pleasure, and these feelings are intimately tied to the neural system for processing reward. This review will (1) examine the brain regions in humans that are associated with reward processing in addition to areas that have altered activity while listening to pleasant music, (2) demonstrate that the symptom of anhedonia that characterizes major depressive disorder (MDD) is largely due to reward system dysfunction and abnormal dopamine activity, and (3) consider the field of music therapy as a potentially successful treatment for people with MDD due to the ability of music to activate the brain's reward system. This review concludes that music therapy, specifically improvisational music therapy, is a promising complementary treatment method for those with MDD, though further research is needed to clearly explain its efficacy and demonstrate its potential to alleviate symptoms of MDD and other disorders that are associated with reward circuit malfunction and/or aberrant dopamine activity.

Introduction

Music, an art form which nearly every human society has developed, not only influences our emotions, but can also become an expression of the emotions which we consciously feel. One of the most important powers of music is its ability to elicit intense feelings of pleasure. In this sense, the term "emotion" refers to the relatively brief, often unconscious physiological and psychological responses to a particular external or internal event (Juslin, Barradas, & Erola, 2015). "Feelings of pleasure," alternatively, correspond to the conscious subjective awareness of a number of components related to positive emotion, such as affect, mood, and various biological states, such as hunger. While most studies have focused on neural activation based on the acoustic and cognitive components of music, little is known about its basis as a rewarding stimulus (Menon & Levitin, 2005). Because it has long been acknowledged that music can evoke pleasurable feelings that are intimately tied to the brain system for processing reward, research in recent years has delved into the neural mechanisms underlying the relationship between music and activation of the so-called reward system. Though this mesocorticolimbic pathway and related structures are involved in processes other than reward, such as responses to aversive stimuli and both positive and negative reinforcement, for the purposes of this paper it will be referred to as the reward system (Volman et al., 2013). Given the involvement of the reward circuit in both music-evoked emotion and major depressive disorder (MDD), these findings must be integrated to better explain and advance the field of music therapy as an evidence-based treatment method.

Music as an Abstract Reward

Typically, the human reward system is activated by physical stimuli. This can be in the form of primary rewards, such as food and sex that are necessary for survival, or secondary rewards, like money or other tangible items (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). However, humans have developed a unique cognitive ability to derive pleasure from abstract stimuli. Music, considered by some as an example of one such abstract stimulus, is not a primary or secondary reward in the strict sense, but through generations and across cultures continues to provide a source of pleasure (Salimpoor et al., 2011). Because music is able to utilize the neural processing of reward through the same mechanisms as other more biologically-salient stimuli, this shows how human cognition has

evolved to accommodate more complex classifications of reward (Blood & Zatorre, 2001). When taken from an evolutionary standpoint, this seemingly odd capability of an abstract stimulus becomes clearer. Because music has often been experienced in a social setting, activation of the reward system encouraged interpersonal relationships and cooperative efforts through sharing pleasurable feelings with others. It is believed by some researchers that music then became a source of social cohesion and the neural circuitry underlying this adaptive mechanism was passed on from generation to generation (Brown, Martinez, & Parsons, 2004).

A major signal component required for normal reward processing is the neurotransmitter dopamine, which has been shown to be altered in people with MDD (see discussion below) (Tremblay et al., 2005). One of the main sources of reward-related dopamine signaling in the brain is the ventral tegmental area (VTA), and a major target for these cells is the nucleus accumbens (Menon & Levitin, 2005). Other main targets of the VTA are the prefrontal cortex, an area associated with decision making and planning, and the dorsal striatum, implicated in habit formation. The VTA also releases dopamine through projections to the amygdala and the anterior cingulate cortex (ACC), as both regions are centrally involved in emotion-related learning and subjective experience (Lepping et al., 2016). The ACC is typically divided into two subregions: ventral (vACC) and dorsal (dACC). Both areas receive input from the prefrontal cortex in addition to the VTA and are involved in positive and negative emotional processing. However, the vACC is mainly activated by emotional stimuli while the dACC is more active during cognitive tasks (Lepping et al., 2016). The ACC is not only involved with emotion generation, but emotion regulation as well. Along with other regions associated with emotion regulation, the ACC plays a role in appraising emotional stimuli and also producing emotions that are appropriate for a given context. People with MDD struggle with emotional regulation, likely as a result of abnormal ACC signaling and reduced ACC volume (Donofry, Rocklein, Wildes, Miller, & Erickson, 2016).

When a stimulus activates the VTA and causes dopamine release in its various target regions, the experience will be felt as rewarding. These reward-related experiences in humans, which are linked to dopamine activity, will be remembered by creating associations between specific stimuli and pleasure, which is useful for directing future behavior. This indicates that dopamine plays a central role in the motivational processes that lead humans to seek out a particular rewarding stimulus (Bressan & Crippa, 2005).

Dopamine release from the VTA is critically important for reward processing because the neurotransmitter is implicated in motivation, reward-seeking behaviors, and working memory (Stegemoller, 2014). All of these cognitive functions are necessary for potentially rewarding stimuli to effectively activate the reward circuit and for feelings of pleasure to be elicited. For example, some types of drugs, such as cocaine and amphetamines, are able to produce pleasurable feelings by disrupting the normal activity of dopamine and increasing extracellular dopamine concentrations throughout the brain. After dopamine is released, excess neurotransmitter usually is taken back up by the cell and re-packaged for later use. However, cocaine and amphetamines prevent this process from occurring, allowing dopamine to exert its effects on target neurons for a longer period of time. Amphetamines also bind to proteins that transport excess dopamine into the neuron and, once across the neuronal membrane, stimulate the release of dopamine back into the synapse. As a result, these drugs create highly intense, long-lasting feelings of pleasure (dela Pena, Gevorkiana, & Shi, 2015).

Evidence that music, specifically, activates reward-related circuitry in humans has been provided using neuroimaging methods. Utilizing functional magnetic resonance imaging (fMRI), which uses blood flow as a measure of brain activity, Menon and Levitin (2005) observed significant activation in the nucleus accumbens and VTA in response to self-reported pleasurable music listening. They also noted increased activity in the left and right inferior frontal cortex and the ACC. Because pleasant music was considered a rewarding stimulus, activation of these areas was expected, but still a

necessary first confirmation in humans. Moreover, there were significant correlations between ongoing activity in the nucleus accumbens and VTA, nucleus accumbens and hypothalamus, and VTA and hypothalamus while listening to pleasant music (Menon & Levitin, 2005). This indicates that the nucleus accumbens, the VTA, and the hypothalamus (a region that regulates autonomic responses), are highly interconnected during music processing. Because the nucleus accumbens and VTA are known to play crucial roles in the neural reward circuit, these findings suggest that music can also serve as a source of reward system activation and stimulate dopamine release.

Additional studies have also implicated the neural circuit for reward in response to music listening, both during anticipation of musically-elicited feelings of pleasure and during actual peak emotional responses. Salimpoor et al. (2011), based on the results of their fMRI study, reported increased activity of the caudate and nucleus accumbens during anticipation of pleasure while listening to pleasant music as compared to neutral music. While the caudate became less active during subjects' peak feeling of pleasure, activity in the nucleus accumbens continued to increase. The caudate, a subregion of the striatum, has connections to the sensory and motor cortices and is important for establishing stimulus-response associations (Salimpoor et al., 2011). The dorsal striatum, also known as the caudate nucleus, plays a role in encoding a specific stimulus as one that elicited positive feelings so that in the future it will be remembered as a pleasurable experience, which helps guide future reward-seeking behaviors (Valentin & O'Doherty, 2009). As a result, this area may be crucial for creating the association between pleasant music and reward. Since the nucleus accumbens is a main target for dopamine, these results also suggest a mechanism by which dopamine can contribute to the subjective feelings of pleasure over time. Taken together, these results show that music can be perceived as a reward in humans and can activate the same dopaminergic pathways as other more tangible rewards do. If music can stimulate dopamine release, then this begins to explain why musical emotional experiences are sought out by many people today and have been throughout history (Salimpoor et al., 2011).

In addition to reporting brain regions which increased activity during pleasant music, Blood and Zatorre (2001) also noted several areas where activity levels decreased from baseline during music listening. Using positron emission tomography (PET) scans, which used blood flow as a measure of brain metabolism, they observed decreased blood flow to the left and right amygdala, left hippocampus, and ventromedial prefrontal cortex while listening to pleasant music. On the contrary, activity increased in the left ventral striatum, dorsomedial midbrain, and anterior cingulate cortex under the same conditions. Interestingly, these regions are known to be directly affected by dopaminergic neuronal projections and are also more active while listening to pleasant music. The authors also noted increased activity in the supplementary motor area and cerebellum, both areas involved in movement and motor control. As music often produces an inclination to move or dance, activation in these regions is unsurprising – though whether this activation is related to the experience of pleasure is as yet unclear. Overall, these results are consistent with the findings of Salimpoor et al. (2011) and Menon and Levitin (2005), further suggesting that pleasant music activates the reward circuit.

Due to the relatively poor spatial resolution of PET scans, it is unclear whether activity in the midbrain was localized to the VTA or also to the periaqueductal gray region (PAG) or the pedunculopontine tegmental nucleus (PPT) (Blood & Zatorre, 2001). However, both are also thought to be involved in reward processing. The PAG has many opioid receptors and thus is associated with reward derived from opioids, such as endorphins. Using the chemical naloxone, these opioid receptors can be blocked, which can decrease or inhibit subjects' subjective feelings of pleasure in response to pleasant music. The PPT, on the other hand, is innervated by the nucleus accumbens and projects to areas including the VTA, thalamus, and amygdala. This region of the midbrain is hypothesized to be involved in creating associations between drugs and reward (Blood & Zatorre, 2001). This means that the PPT may be involved in learning that a certain

drug elicits pleasurable feelings, and thus may also be important for establishing the memory that pleasant music produces similar feelings. Even though it remains unclear whether one or both of these areas were activated by music (in addition to the VTA), both are involved in reward processing. As the PAG and PPT are not typically regarded as major parts of the reward system, this indicates that pleasurable music has the ability to activate a wide range of regions within the reward circuit to contribute to greater pleasurable feelings, and also raises questions about where the boundaries of the so-called reward system lie (though this discussion is beyond the scope of this paper) (Volman et al., 2013).

Another mechanism by which music may achieve maximum feelings of pleasure is by simultaneously activating the reward system and inhibiting areas that are associated with processing negative emotions (Blood & Zatorre, 2001). Both the amygdala and hippocampus have been shown to be active during emotions that are considered negative, such as fear, and tend to be overactive in people with major depressive disorder. While this is certainly not their only function, both regions do play a role in experiencing negative emotions. Blood and Zatorre (2001) showed that while subjects listened to pleasant music, activity in the right and left amygdala and left hippocampus decreased. Additionally, the amygdala and hippocampus receive direct inhibitory input from the nucleus accumbens. This suggests that when the nucleus accumbens and therefore the reward circuit are active, the amygdala and hippocampus, areas that are involved in processing negative emotions, are inhibited. As a result, music can both activate the reward system and inhibit pathways related to the processing of negative emotions, presumably leading to a maximal pleasure response signal. These findings are especially relevant to the discussion below of music as a potential treatment for people with MDD, as they have difficulty experiencing pleasure as well as hyperactivity in areas involved in processing negative emotions.

In addition to activating brain regions that mediate the subjective feeling of pleasure, music also causes changes in autonomic nervous system functioning that are associated with many other types of pleasurable experiences. Since feelings of pleasure can be difficult to measure quantitatively, physiological responses that occur are often used to judge emotional arousal (Salimpoor et al., 2011). This includes frequencies of "chills" or "goose bumps" experienced while listening to pleasurable music as well as measures of autonomic activity changes, such as heart rate, respiration rate, and skin conductance. These same autonomic reactions accompany pleasure responses to other rewarding stimuli, like a favorite food. Pleasurable music listening results in significantly higher autonomic nervous system activity. Increases in heart rate, respiration rate, and skin conductance and decreases in body temperature and blood volume pulse amplitude, or the amount of blood pumped by a single heartbeat, are typical. Intensity and frequency of chills has been shown to be significantly related to all five of these measures of autonomic nervous system arousal (Salimpoor et al., 2011). Since the hypothalamus is involved in monitoring autonomic responses, it makes sense that listening to pleasurable music would activate this specific region, as observed by Menon and Levitin (2005). These results show that pleasant music elicits the same physiological responses as many other typical primary and secondary rewards (such as the psychostimulant drugs discussed above), providing further evidence that music can itself act as a rewarding stimulus.

In summary, studies have clearly shown that music can elicit physiological responses and activate brain reward regions associated with the processing of primary and secondary rewards (Blood & Zatorre, 2001; Menon & Levitin, 2005; Salimpoor et al., 2011). As the VTA is the site of dopamine production and projects directly to the nucleus accumbens, these areas are typically considered as fundamental components of the neural basis of reward. Listening to pleasant music elicits feelings of pleasure, activates the reward circuit, and should be considered as a type of abstract reward. This is of critical importance because it illustrates that the reward system in humans does not need an explicit reward, such as food or money, to become activated (Menon & Levitin, 2005). It

also suggests that pleasant music may have the potential to be an incredibly useful treatment option for disorders that are associated with an aberrant reward system and dopamine dysfunction, as in the case of MDD.

Reward System Dysfunction in Major Depressive Disorder

Research in recent years has begun to explore neural reward mechanisms as targets for treatment of certain neurological and psychiatric disorders. This is largely due to the ability of dopamine and the reward regions themselves to undergo synaptic and connective alterations in circuitry. Because drug use, environmental factors, and childhood development are known to induce changes in the brain's reward circuit, it is hypothesized that this system can be artificially altered using medication or modified through naturally rewarding stimuli, particularly pleasant music (Tremblay et al., 2005).

One such illness that this approach may be particularly effective for is major depressive disorder (MDD), given the changes noted throughout the reward-related circuits. Although other disorders such as schizophrenia and generalized anxiety disorder may also benefit from music therapy for similar reasons, this is beyond the current scope of this paper. MDD is characterized by the symptom of anhedonia, a markedly reduced interest in activities or experiences that used to elicit pleasure, which can include music listening (Tremblay et al., 2005). Additionally, abnormal activity of some neurotransmitters and neuroendocrine systems, such as serotonin, dopamine, and norepinephrine, are common in those with MDD (Tremblay et al., 2005). Since dopamine malfunction and anhedonia are both associated with MDD, this implicates the neural reward system in the pathophysiology of MDD and also suggests that pleasant music may be able to selectively target this circuit in order to alleviate symptoms.

Normal dopamine activity is essential for a fully functioning reward circuit, but this is typically not the case for people with MDD. For example, a drug which is known to greatly stimulate dopamine release throughout the reward system in healthy people, dextroamphetamine, results in much greater feelings of pleasure in those with MDD (Tremblay et al., 2005). Those with MDD were hypersensitive to the drug, meaning they experienced heightened feelings of pleasure relative to the control group. Furthermore, the degree of hypersensitivity was associated with the severity of anhedonia reported. The fact that subjects with MDD experienced a hypersensitivity to dextroamphetamine indicates that dopamine release or activity is not functioning correctly in these people and supports the hypothesis that the reward system is implicated in the symptoms of MDD (Tremblay et al., 2005).

Additional evidence for the idea that reward system malfunctioning is involved in MDD lies in the brain regions that showed decreased activity compared to healthy subjects. These areas include the right ventrolateral prefrontal cortex, caudate, and orbitofrontal cortex (Tremblay et al., 2005). In terms of neuroimaging, often times the regions that are deactivated are just as important as those that become more active. The caudate, specifically, is important in that it is associated with reward processing and contains dopaminergic projections. The researchers believed that dextroamphetamine (which may have inhibited receptors for glutamate) results in the disinhibition of dopaminergic neurons, cells that are normally inhibited in people with MDD. This dextroamphetamine-induced disinhibition could explain the hypersensitivity they experienced (Tremblay et al., 2005). If exposure to pleasant music can result in the same process of dopamine disinhibition, then it would be an invaluable treatment for MDD patients, as it would more naturally produce intensely pleasurable feelings.

Another possible mechanism of irregular dopamine activity is through D2 and D3 dopamine receptors. These receptors are concentrated in the temporal cortex, providing an extrastriatal target for dopamine. However, if these receptors are abnormally blocked in people with MDD, dopamine cannot effectively bind and produce its cascade of effects. This decreased accessibility of D2 and D3 dopamine receptors has been associated with anhedonia, a key symptom of MDD (Tremblay et al., 2005). Because MDD is associated with altered brain

functioning in areas implicated in the neural basis of reward in addition to abnormal dopamine activity, it is clear that a key factor underlying anhedonia as a symptom for MDD is irregular reward circuit activity. Music has been shown to activate areas within the reward system, and thus it may be a method for correcting the malfunctioning reward circuit that underlies the anhedonia seen in MDD.

Music Therapy: Integration of Music and Reward for MDD

As has been previously discussed, music is an effective source of activation for the brain's reward system and this circuit can induce changes in neuronal wiring. Because major depressive disorder is associated with a malfunctioning reward circuit, music could be a potential therapeutic tool. This approach could be applied to other neurological and psychiatric disorders as well, such as schizophrenia and bipolar disorder (Castillo-Perez, Gomez-Perez, Velasco, Perez-Campos, & Mayoral, 2010). In the case of MDD, listening to pleasant music could alter the reward pathways and thus alleviate symptoms, such as anhedonia, and contribute to more intense feelings of pleasure.

Research on the therapeutic use of pleasurable music for MDD has only recently gained traction. A review of current studies investigating the potential effects of pleasant music on symptoms of MDD was conducted by Chan, Yang Wong, and Thayala (2011). Of seventeen studies included, eleven showed clear evidence of reduced self-reported depressive scores after repeated sessions of music listening. These beneficial results continued even after the music listening sessions were stopped, indicating that the improvement in MDD symptoms in response to pleasant music could be long-term. An important component of this research is that all music listening periods did not involve the direct involvement of a music therapist (Chan et al., 2011). The reduced depressive symptoms were produced entirely by the music, which shows the power of pleasant music to alter cognitive functioning and also demonstrates that music is a treatment available to anyone with MDD.

Additionally, this form of music therapy may even be more effective than more traditional forms of psychotherapy in treating symptoms of major depressive disorder. In a study by Castillo-Perez et al. (2010), participants with MDD were either exposed to pleasant classical music as music therapy or underwent typical psychotherapy treatments. After eight weeks, the music therapy group displayed more improvement in depressive symptoms than the subjects who participated in psychotherapy (Castillo-Perez et al., 2010). This demonstrates that, not only is music an effective tool in decreasing levels of depression, but it may also be more successful than psychotherapy under at least some conditions. As this is the most common form of therapy currently used to treat depression, these results suggest that incorporating music into existing therapeutic methods may have significant benefits for treatment outcomes. With the recent development of music as a formal method of therapy, some therapists have begun to do exactly this.

While simply listening to pleasant music is considered one form of music therapy for depression, others more directly involve the patient in the musical experience. One example of this is improvisational music therapy, in which both the patient and the therapist use musical instruments, oftentimes drums, to interact. The therapist carefully listens to the patient's improvised rhythms and actively encourages the patient to express their emotions through a form of nonverbal communication. This can lead to a process of self-discovery, allowing the patient to gain insight into their feelings that cannot necessarily be achieved using words alone (Erkkila et al., 2011). The therapist can then utilize these realizations in later reflective discussions to better explore the patient's depressive thoughts and emotions. Another important component of improvisational music therapy is that it can allow for a deeper, more meaningful relationship to develop between the patient and therapist. Through music-making, both the patient and the therapist are encouraged to experience each other differently than in traditional psychotherapy sessions. This allows them to relate to each other in a way that simply talking may not achieve, building a stronger patient-therapist bond (Maratos, Crawford, & Procter,

2011). Given these characteristics of improvisational music therapy, it may be able to help break down barriers that prevent patients from discussing their feelings, which is often the case for those with MDD, and lead to more successful therapy sessions.

Additionally, Erkkila et al. (2011) demonstrated that this form of therapy is more effective in improving symptoms of depression, as well as anxiety and overall brain functioning, than standard therapy alone. Based on results from various psychiatric tests (i.e. Montgomery-Asberg Depression Rating Scale, Hospital Anxiety and Depression Scale, and Global Assessment of Functioning), subjects who participated in improvisational music therapy had significantly greater decreases in depression and anxiety levels and increases in overall functioning compared to those who engaged in traditional psychotherapy. These findings demonstrate that integrating improvisational music-making with more traditional psychotherapy adds another dimension to the therapeutic approach that can significantly improve the symptoms of those with MDD. However, a similar study should be performed using fMRI to assess symptoms of depression, anxiety, and general brain functioning to corroborate the results obtained by Erkkila et al. (2011).

Improvisational music therapy is successful in reducing levels of depression, but there are several factors which are thought to contribute to this phenomenon. One aspect is that, through active music-making, the patient must partake in physical movement. The benefits of physical exercise for preventing depression and reducing its symptoms have been well documented, but in this case the active participation in music-making encourages physical experiences with others (Maratos et al., 2011). This dimension of music therapy seems to be important to MDD patients, and thus is thought to play a role in the effectiveness of improvisational music therapy (Erkkila et al., 2011; Maratos et al., 2011). Additionally, producing music is both a mentally and physically engaging task and becomes inherently social as the patient must interact with the therapist on an intimate, emotional level. For people with MDD, activities that incorporate both of these elements are incredibly important due to their general lack of motivation to seek out social encounters that also involve emotional expression. This form of therapy may be a particularly useful strategy for MDD patients or those affected by other disorders, such as generalized anxiety disorder or schizophrenia, who can be unusually difficult to engage (Maratos et al., 2011).

Most importantly for this argument, it is hypothesized that a major contributor to the success of all forms of music therapy in reducing the severity of depression is its ability to activate the neural reward system. As previously discussed, MDD involves a malfunctioning reward system and abnormal dopaminergic activity, typically associated with low levels of both dopamine and its receptors (Castillo-Perez et al., 2010). By activation of many of the brain regions associated with reward processing, music can also elicit pleasurable feelings and therefore increase positive affect in patients with MDD (Castillo-Perez et al., 2010). Given these findings, it seems plausible that the music component of music therapy can increase dopamine release and its transmission throughout the brain in patients with MDD, just as listening to pleasant music does in those without the disorder. Up-regulation of dopamine release due to music can then, to some extent, combat the dopamine dysfunction that is associated with MDD and lead to reduced symptoms. Even though MDD is characterized by anhedonia, a lack of interest in previously pleasurable experiences, music therapy provides a means by which this symptom can directly be targeted through activation of the reward circuit.

Music as a therapeutic tool has many additional benefits outside of possibly being an effective method for alleviating MDD symptoms. However, few studies have been conducted that clearly demonstrate the success of music therapy. Initial research suggests that it is a promising therapeutic method for reducing symptoms of MDD, but further investigation is needed to clarify its potential efficacy. As opposed to many of the oftentimes costly medications currently available to treat MDD that can cause unwanted side effects, tolerance, and withdrawal, music is inexpensive and carries

no unforeseen health risks. Additionally, even without the assistance of a therapist, music has been shown to decrease levels of depression in people with MDD. In this form of music therapy, there is no added cost of the therapist because the treatment can be self-administered (Castillo-Perez et al., 2010). This makes it incredibly easy for people with MDD to increase their positive affect through music, so long as music listening sessions are frequent and consistent. Though a therapist is needed in the case of improvisational music therapy, this provides an altogether different set of benefits.

Improvisational music therapy possesses distinct characteristics that may ultimately reveal it to be the most effective method of music therapy – although much research is needed in this area to confirm such a claim. As previously discussed, this therapeutic program is unique in that it incorporates physical movement. The depression-reducing effects of physical activity in combination with those produced by musically-activating the reward system may lead to a more significant decrease in MDD symptoms than either one can achieve alone. Additionally, incorporating more traditional psychotherapy measures into music therapy adds another dimension of beneficial effects. Psychotherapy has proven successful in encouraging patients with MDD to verbally communicate their thoughts and feelings so as to more adequately deal with them. Using improvisational music therapy integrates the verbal conversation aspect of psychotherapy with the nonverbal emotional expression through music-making into a single therapeutic process (Maratos et al., 2011). In so doing, the power of improvisational music therapy to alleviate symptoms of MDD becomes greater than either music therapy or psychotherapy individually because the beneficial effects of each method can add upon each other. Using these criteria, improvisational music therapy can be seen as the most successful treatment method for reducing symptoms of MDD.

While there are many forms of music therapy available today, all succeed in alleviating symptoms of MDD by activating the neural reward circuit. However, most music therapists and researchers who investigate the field do not approach music therapy from a reward circuit point of view. Knowledge about the effectiveness of music in alleviating symptoms of MDD is becoming widespread, but oftentimes those who practice music therapy are unaware of the neural mechanisms underlying these benefits, mainly that music activates the reward system and increases dopamine levels throughout the brain. One way to utilize this information might be to tailor the music to the preferences of individual patients, for example using the patient's choice of musical instruments during improvisational music therapy sessions. This may be an effective way to develop subjective, nonconscious connections between patient and therapist that often underlie successful relationships. Additionally, promoting positive affect and reducing cognitive decline through music that creates constructive, personal associations is currently being used as a complementary treatment for Alzheimer's patients (Fang, Ye, Huangfu, & Calimag, 2017). People with MDD also exhibit decreased cognitive abilities, which might be another connection between MDD and music therapy as an effective treatment. The main aim of improvisational music therapy for MDD, and all forms for that matter, is to produce the greatest decrease in depressive symptoms. Because this is likely achieved mainly through activation of the brain's reward system, approaching music therapy from this standpoint will result in improved methodology, organization, and outcomes for a field that has initially proven remarkably successful in alleviating symptoms of MDD.

Conclusion

In conclusion, this paper has demonstrated that the concepts of music, reward, and depression are highly integrated. Listening to pleasant music has been shown to activate many of the same brain regions that are associated with other types of reward processing, mainly the VTA, nucleus accumbens, prefrontal cortex, and ACC (Blood & Zatorre, 2001; Menon & Levitin, 2005; Salimpoor et al., 2011). Because MDD is a disorder associated with reward system dysfunction and abnormal dopamine activity, music has begun to be explored as a treatment which specifically targets this circuit to reduce

symptoms. The field of music therapy, and improvisational music therapy in particular, initially seems to be effective in alleviating depressive symptoms. This is not to say that music therapy can completely replace more traditional forms of psychotherapy or medication, but it should perhaps be used as a complement to these other treatment methods in order to produce the greatest reduction in MDD symptoms possible. While research has not yet explored specifically whether music-making activates the neural reward system, if such an fMRI study was conducted then it would likely find increased activation of the VTA, nucleus accumbens, ACC, and medial prefrontal cortex. These regions are all considered to be major components of reward processing in the brain. Based on the fact that listening to pleasant music activates these same areas and that improvisational music therapy reduces the symptom of anhedonia that characterizes MDD, the inference is that music-making also has the ability to act as a reward and may contribute to long-term changes if used in a therapeutic manner – although the parameters for such a successful treatment are currently entirely unexplored. If improvisational music therapy results in reward system activation, this largely explains why it is so successful in reducing symptoms of MDD and increasing positive affect. While music therapy certainly can be beneficial for people with MDD, it may also prove effective for other psychiatric disorders including bipolar disorder, schizophrenia, generalized anxiety disorder, and even Parkinson's disease – all of which, for instance, involve periods of low mood and anhedonia in addition to reward system malfunction and/or abnormal dopamine activity. As music and music-making begin to be viewed as effective tools for alleviating symptoms directly as a result of their ability to activate the brain's reward system, music therapy will have the potential to become a mainstream treatment method not only for MDD, but for other psychiatric and neurological disorders as well.

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