Full-Length Article

Individuals with Acquired Brain Injuiry (ABI): *Implications for Music Therapy in the Treatment of Depression*

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Abstract
Stroke is a prevalent disease, and the leading cause of neurological disability worldwide. The emotional impact a stroke may have on a person's wellbeing and the risk of depression can affect readiness to engage in rehabilitation, functional outcomes, and the ability to reintegrate socially. Depression often goes undiagnosed and may be untreated. Music and music therapy have the potential to access and effect change concurrently in multiple domains, making it a valued method for facilitating non-pharmacological, therapeutic change while supporting a person's emotional needs. Music therapy interventions may provide motivation for participation in rehabilitation, as well as facilitate goal acquisition in physical, psychosocial, emotional, communicative and cognitive domains. This paper explores the role of motivation, evidence of music-induced affective responding, therapeutic effects of music interventions on mood, physiological and neural correlates, social interaction, music therapy implications for individuals recovering from acquired brain injury, and future directions.

Keywords*: depression, acquired brain injury, stroke, emotion, music therapy* multilingual abstract | **mmd.iammonline.com**

Introduction

Music therapists treat persons recovering from an acquired brain injury (ABI), including those recovering from stroke, using a variety of music therapy approaches and techniques [1]. In Canada, at a prevalence of 1.15%, over 400,000 persons are living with the effects of a cerebrovascular incident (CVA), ranging from mild to severe. This number will rise to between 654 and 726 thousand persons by 2038 [2]. Statistics suggest one-third of persons who experienced a stroke die, one-third recover fully, while one-third suffer from long-term disability [3]. Consequences of a CVA may include abulia, apraxia, confusion, depression and hemiplegia [4].

Emotional sequelae can impact one's readiness to engage in rehabilitation, influencing functional outcomes, and the ability to reintegrate socially. Although close to 30% of patients develop depression either in the early and/or late stages following a CVA [5], the condition often remains undiagnosed and inadequately treated. Post-stroke conditions, including aphasia and changes in sleep patterns, may mask symptoms of depression, rendering diagnosis difficult [6]. Risk factors for post-stroke depression include functional impairment, cognitive deficit, stroke severity, and a prior history of depression. Given concerns of potential side effects, prophylactic treatment with antidepressants is not recommended [7]. Similarly, anxiety frequently co-occurs; however, treatment with anxiolytics incurs the risks of possible adverse reactions [3].

Music has the potential to access and effect change in multiple domains simultaneously [8], and as such is a valuable medium for facilitating non-pharmacological, therapeutic change. In rehabilitative music therapy, goals are restorative, addressing functional movement as well as psychotherapeutic needs, including feelings arising from the recovery process [9]. Positive emotions have been shown to exert a strong influence on post-stroke gains of motor and cognitive function [10]; however, feelings of sadness and frustration, with concomitant reduction in self-confidence and sense of pride, may predominate [11]. Chronic stress is a contributing factor to anxiety and depression, as well as to somatic disorders, including hypertension and immune dysfunction [12]. Music, which activates the emotion and reward system in the brain in addition to engaging a multi-sensory and motor network [13], may serve to enhance mood and reduce stress [14]. Although an integral part of music therapy, affective considerations have yet to be explored systematically in studies of music therapy interventions.

A review found initial evidence for efficacy of music-induced emotion and mood states that could subsequently modulate negative/positive self-estimations, motivation levels, and coping abilities [15]. Music in Psychosocial Training and Counseling (MPC), a Neurologic Music Therapy (NMT) technique, is designed to help individuals with neurologic disorders improve psychosocial functioning. In this practice, music performance is used "to address issues of mood control,

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affective expression, cognitive coherence, reality orientation, and appropriate social interaction to facilitate psychosocial functions" [16, p.197]. Goals include identification and expression of affect and mood regulation, as well as development of social competence and self-awareness [17].

Psychosocial and functional aspects of recovery are often addressed separately in rehabilitation, as persons working in this area typically do not incorporate affective techniques with physical techniques. Indeed, in the *Handbook of Neurologic Music Therapy* [18], affective considerations, which are central to MPC and to Associative Mood and Memory Training (AMMT), are only briefly referenced in techniques for functional rehabilitation. An example of combining techniques over the course of therapy with separate aims included: Rhythmic Auditory Stimulation (RAS) to address gait parameters, and songwriting to sustain motivation for RAS and address socio-emotional difficulties in a person with a traumatic brain injury (TBI) [19].

Is an integrative approach to psychosocial and functional rehabilitative needs possible? A three-pronged Model of Music Therapy in Neuro-disability (MIND), involving restorative, psycho-social-emotional, and compensatory approaches has been described by Daveson [20]. The main premise of this multi-focused, patient-centered and patient-led meta-model is that different types of needs present at one time in persons with brain injury or neurodegenerative disease, and that the use of a single music therapy model may be inadequate to address such complexity. This work identifies NMT as an example of the *restorative approach* focused on functional gains [20]. In explaining the *psycho-social-emotional approach,* earlier work by Wheeler, who delineated three levels of psychotherapeutic practice, is cited. Wheeler built upon two of these practice levels in outlining and elaborating upon MPC [17]. The first level is activity therapy, in which goals and behavioral change are achieved through activity, without emphasis on understanding why such changes may be occurring. This may be beneficial for patients with post-stroke frontal lobe damage affecting cognitive processing ability. The second is an insight-oriented form of music therapy with re-educative goals focusing on the here and now, feelings, and interpersonal responses. It is process-oriented, and designed for individuals who can also benefit from the verbal aspects of this practice. The *compensatory approach* in delineating MIND focuses in particular on the needs of individuals with neuro-degenerative disease [20]. Daveson provides a decision flowchart that recommends: (1) establishing the general reason for referral (2) establishing the treatment approach (*restorative, psycho-social-emotional* and/or *compensatory*) (3) establishing goal foci with the patient (where possible) (4) writing goals that are specific, measurable, attainable, relevant, and time-related, if possible in conjunction with the patient (5) identifying the music therapy model to use to address each goal, in accordance with the required approach (6) identifying techniques to address goal foci, in line with the required approach and available evidence. It is noted that there may be overlap of approaches; for example, some patients with potential to regain functional skills may require psycho-social-emotional work to help decrease feelings of frustration.

Post-stroke emotional sequelae may impede ability to commit to rehabilitative goals, and those with frontal lobe damage, unable to understand their emotional liability, could be challenged to engage in such a process. The MIND approach appears to assume that the NMT model covers solely restorative functional aspects of rehabilitation; however, techniques such as MPC addressing psychosocial needs have also been delineated. An integrative approach within a single model incorporating clearly defined NMT goals involving, for example, activity-oriented MPC in conjunction with restorative functional NMT goals, may help promote whole person rehabilitative care [21].

In this paper the role of motivation, evidence of music-induced affective responding, the therapeutic effects of music on mood, physiological and neural correlates, and social interaction will be discussed. Further, music therapy implications for individuals recovering from ABI are shared alongside future directions.

The Role of Motivation

Cortical plasticity, critical in neural network reorganization following brain injury, is enhanced in animal studies when stimuli are behaviorally relevant and motivationally stimulating [22]. Individuals may find the rehabilitation environment to be non-motivating [6], and depression characterized by apathy may lead to a lack of perseverance. Changes to cognition, (i.e. poorer memory and higher levels of distractibility), and feelings of isolation may compromise commitment to rehabilitative goals. Poulsen, Rodger, and Ziviani [23] developed a self-determination continuum, with progression from external regulation to intrinsically motivated engagement and development of an internal locus of control. This continuum suggests providing opportunities to engage in motivationally stimulating therapeutic activities calibrated to the individual's ability level, which may promote a greater sense of self-efficacy.

Emotions serve to either facilitate or inhibit intrinsically motivated behavior, amplifying positive or negative affective arousal. They are viewed as the affective "charge" that drives and shapes motivational engagement [24]. A review of literature pertaining to therapeutic mechanisms underpinning affective considerations follows.

Evidence of Music-induced Affective Responding

Evidence of affective modulation emerges in research involving infants' responses to music. The way infants are sung to may be more important than what is being sung [25]. Expressive features, in particular a loving tone, predicts the degree of infant preference as indicated by their looking time.

While infants prefer higher-pitched versions of play songs, which stimulate arousal levels, lower- pitched versions of lullabies are preferred [26]. A preference in infants for affectively positive relative to affectively neutral speech, and more sustained effects on infant arousal as a result of live maternal singing compared to speaking has been noted [27]. Infant-directed singing has been found to be more effective than speech in delaying the onset of infant distress [28]. In addition, infants listened longer to auditory test stimuli with accented beats matching the pattern they were bounced to, suggesting early vestibular-auditory interaction underlying musical behaviour development [29].

In a controlled laboratory experiment, researchers manipulated the tempo and mode of instrumental music selections (from J.S. Bach for harpsichord) to determine listeners' perception of the emotions conveyed by the music and their emotional responses to music [30]. Happiness ratings were high for fast-tempo, major-key stimuli; sadness ratings were high for slow-tempo, minor-key stimuli. Music with mixed cues of fast-minor and slow-major, garnered mixed emotional responses of higher happiness and sadness ratings. The researchers found feeling and perception ratings to be highly correlated, with affective responses mediated by listener perception of the emotions conveyed by music.

A qualitative study into the use of music for emotional self-regulation by adolescents, adults, and older adults found that typical features of regulation in all age groups included selection of music based on current rather than target mood, and goals of mood improvement [31]. Individual differences included preferences for certain strategies, with some using music as a distraction from a sad mood, and others reinforcing and contemplating current mood state. Interestingly, other research has found that following induction of happy, neutral, or sad moods, listeners preferred happy music after a happy or neutral mood induction; however, after a sad mood induction, this preference disappeared [32]. Sad moods also heightened listeners' perception of sadness in music, reinforcing the researchers' contention that 'misery loves company.'

Possible explanations for the above-noted effect have been offered [33]. Individuals experiencing depression often experience a sense of loneliness and perception of being misunderstood by others. Happy music reinforces this sense of lack of understanding, whereas sad music connects listeners to others experiencing this affective state. One theory is that prolactin, a hormone produced by the pituitary gland that has a tranquilizing, consoling effect, may be released in response to sad music, and that this in turn has a mitigating effect on mood [33].

An Experience Sampling Method (ESM) was used to explore the prevalence of different musical emotions in everyday life [34]. Participants completed questionnaires seven times a day at random intervals for two weeks. Music affected how participants felt in 64% of the music episodes, with happiness-elation and nostalgia-longing more frequent in episodes with musical emotions. Anger-irritation, boredom-indifference, and anxiety-fear were recorded more frequently in episodes with nonmusical emotions, underscoring the emotion regulating effects of listener-selected music.

Changes in affective responding induced by music have been shown to lead to concomitant changes in cognitive performance, including attention, spatial abilities, processing speed and creativity. Such changes are enhanced when listening to or actively participating in renditions of preferred music, and are thought to be a function of effects on arousal and mood [35-37].

Therapeutic Effects of Music Interventions on Mood

In 2009, a systematic review of all randomized controlled trials examining the efficacy of music therapy among people with depression compared to standard care, or to other psychological or pharmacological interventions for depression was undertaken [38]. Although five studies met inclusion criteria, a meta-analysis was not possible due to variations in interventions, populations, and outcome measures. Four of the five studies reported clinically significant positive effects. A fifth study, which included music therapy as a control treatment examining the effects of cognitive behavior therapy (CBT), found no effect in the music therapy condition. However, groups in this study were not matched for number of participants, treatment dose, or therapeutic framework. Those assigned to CBT received 90 minutes of therapy in groups with a maximum of seven participants, following a structured, coherent approach. Participants assigned to music therapy received 60 minutes per session in groups of 20 people, listening to a variety of music, with no coherent framework. Methodological quality of all five studies, according to the review authors, was low, and although four studies reported greater reductions in depressive symptoms for participants randomly assigned to music therapy, results need to be interpreted with caution. Positively, most participants randomized to music therapy completed treatment (dropout levels were low): an indication that music therapy was viewed as an acceptable form of intervention.

Music therapy targeting mood in stroke patients has been shown to decrease scores on the Beck Anxiety Inventory (BAI) and Beck Depression Inventory (BDI), the latter showing statistically significant changes [39]. Individuals in the music therapy group in this study volunteered to participate, however, and those assigned to the control group did not receive a dose-matched intervention. Though the music therapy intervention involved active participation, including improvisation on a range of instruments, music selection and interventions were not always age appropriate.

A further study [40] investigated the effects of daily music listening on the mood and cognition of acute recovery stage post-stroke patients. Participants were randomly assigned to

either a music, language, or control group. No significant group differences were reported at baseline in cognitive performance or mood. Music and language group participants listened daily for a two-month period to self-selected music or to audio books. In addition to tests of cognitive function, mood was evaluated at baseline, three months, and six months using the shortened version of the Profile of Mood States (POMS). Quality of life was also assessed at three and six months post-stroke using a self-report and a proxy-reported questionnaire. The researchers noted there is typically higher emotional labiality in the acute post-stroke stage, with more stable post-stroke depressive mood emerging after three or four months. As a result, group differences in mood were analyzed cross-sectionally. Results showed significant group differences in depression and confusion at the three-month stage, with the music group depression score significantly lower than the control group, and the confusion score marginally lower. At six months, group differences were marginally significant, with music group members experiencing less depressed and confused mood relative to the control group. No significant group differences were reported on the quality of life measures. As gains were also found in the music group in verbal memory and focused attention, the researchers concluded that music listening in the early post-stroke stage was instrumental in promoting cognitive recovery and improved mood.

Physiological and Neural Correlates

Goldstein [41], the first to research the phenomenon of music-induced chills from strong emotional experiences, found about half the respondents surveyed reported experiencing music-related chills. Researchers hypothesized that intensity of chills would correlate with activity changes in reward/motivation, limbic, para-limbic, and arousal cortical regions [42]. They asked participants to select one piece of music that consistently induced positive emotional responses, including chills. Using positron emission tomography (PET), cerebral blood flow changes (rCBF) were measured as participants listened to their selections. As intensity of chills increased, rCBF increases were observed in brain regions associated with reward/motivation, emotion, and arousal, including ventral striatum and the midbrain (ventral tegmental area). Increases with chills intensity were also observed in para-limbic regions (bilateral insula, right orbitofrontal cortex (OFC), regions associated with arousal (thalamus and anterior cingulate cortex (AC), and motor activity (supplementary motor area (SMA) and cerebellum). Decreases of rCBF were noted in the right amygdala, left hippocampus/amygdala, and ventromedial prefrontal cortex (VMPF). Increases in participants' respiration, heart rate, and electromyogram were also noted, indicating autonomic and psychophysiological responses.

Functional magnetic resonance imaging (fMRI) was used to investigate neural correlates of musical pleasure. Listening to music perceived as pleasant activated the ventral striatum, known to be critical in reward and reinforcement, the anterior superior insula, and the Rolandic operculum. Music listening was found to have the capacity to both up- and down-regulate neuronal activity in the amygdala, hippocampus, parahippocampal gyrus and temporal poles in response to unpleasant and pleasant music [43]. Several studies examining activation of brain structures in response to listening to pleasant music concluded: "music can easily evoke experiences of pleasure, or fun, associated with the activity of a reward pathway involving the hypothalamus, the ventral tegmental area and the nucleus accumbens" [44, p. 134]. In contrast, results of a study involving individuals with specific musical anhedonia [45] indicated that the reward network may not be exclusively involved in the processing of music-evoked emotions, but may involve auditory perceptual areas and integrative regions, including frontal cortices, as well. The authors note that persons with temporal, frontal, or parietal lesions, but not lesions in reward-related structures, have reported loss of capacity to experience music-evoked emotions.

The relationship between emotional arousal and pleasure while listening to music using psychophysiological equipment to record participants' heart rate, blood volume pulse (BVP) amplitude, respiration rate, electro dermal activity or galvanic skin response (GSR), and body temperature has been studied [46]. Since pleasure is a subjective state, the authors suggested individuals are more likely to engage repeatedly in activities which induce a pleasure response. The researchers tested whether the rewarding aspects of music listening are induced by positive changes in emotional state. Participants were asked to provide three to five selections of instrumental music to which they consistently experienced chills. Music selected could not have extra-musical, autobiographical associations, to ensure induced responses were specific to the music rather than acting as triggers for emotional recollections. Music selected was from a range of genres, which increased ecological validity, and included a range of psycho acoustical parameters. Three-minute excerpts representing the most intensely pleasurable section were generated from the selections. To isolate stimulus-driven versus individual response driven changes, participants were asked to rate excerpts they had not previously selected to identify familiar selections rated low on pleasure which could serve as a control. In this way, each excerpt was used once as a stimulus and once as a control, matched with a person who considered one excerpt pleasurable and one neutral.

Participants listened to six musical excerpts: three "chill" inducing pieces and three "neutral" pieces played in random order. While listening, ratings of subjective pleasure in real time were obtained when participants pressed separate buttons to indicate whether the degree of experienced pleasure was neutral, low, or high. A fourth button was pressed when experiencing a chill. A strong positive correlation was found

between subjective ratings of pleasure and autonomic nervous system arousal. Increases were recorded in electro dermal activity, heart rate and respiration rate, and decreases found in temperature and BVP amplitude in conjunction with reports of greater pleasure experienced while listening to excerpts. Intensity of chills was found to be highly correlated with overall pleasure. Significant differences were also found between felt and perceived emotional responses for both arousal and valence. Self-selected music generated ratings of greater similarity between felt and perceived responses than experimenter-selected; a positive correlation was found between felt and perceived valence with listener-selected excerpts, whereas significant differences were found between perceived and felt valence for experimenter-selected pieces. Furthermore, listeners had a more neutral response, reporting less arousal than what they thought experimenter-selected music was intended to convey, whether the perceived emotion be happy or sad. Felt arousal was more strongly correlated with degree of pleasure than felt valence; a strong, positive relationship was found between increases in emotional arousal and reported increases in music listening pleasure.

A number of empirical studies that measure neuroendocrine change in response to music interventions, as well as studies measuring the effects of music on biochemicals serve to further underscore the complex psychophysiological processes accompanying affective response to musical stimuli. Effects of music on biochemicals, including cortisol, dopamine, melatonin, norepinephrine, oxytocin, prolactin, immunoglobulin A, and serotonin have been reported [47-48]. In a review of scientific-inquiry into music-induced neurochemical changes, colleagues found that in spite of methodological limitations, preliminary evidence supports the claim that neurochemical changes mediate the effects of music on health [14]. Evidence of support was found in the domains of reward, motivation, and pleasure; stress and arousal; immunity; and social affiliation.

Social Interaction

In a study investigating the roles of situational factors in emotional reactions to music [49], adult participants reported heightened emotional responses when they listened with a partner as compared to listening alone. Others noted that the human ability to entrain to an external rhythm and participate in music making and dancing likely evolved in a social context [50]. The researchers hypothesized that very young children would be able to synchronize movements to a beat at an earlier age and with greater accuracy in a social than in a nonsocial context. Children ages 2.5 to 4.5 years were asked to drum with a drum sound from a speaker, a drum machine that demonstrated the movement, and with a human partner. Children in all age groups were able to synchronize their drumming better in the social than in the nonsocial conditions. In exploring from a social-perspective the developmental origins of spontaneous, sensorimotor synchronization, the authors advance the notion that drumming with another individual fosters shared intentionality in a joint action task, that there is a distinctly human motivation to share experiences and emotions, and that this is manifested in synchronization of movements during a joint rhythmic activity.

A study to determine if participation in music therapy was effective in enhancing post-stroke patients' mood, social interaction, and engagement in rehabilitation at the acute stage was conducted in 2000 [51]. Measures administered prior to and following treatment included participant self-reports on a 7-point Faces Scale, family rating of participant's mood and social interaction, and staff rating (physical or occupational therapist) of participant's mood and participation in therapy. Results indicated music therapy had an emotional influence on social interaction and participation, with some trends towards improvement in mood, which approached significance on three of the four mood measures. Family members of participants who were more impaired at outset and who were assigned to music therapy reported significant improvement in social interaction. The music therapy interventions were designed to promote interaction, both nonverbally and verbally, through improvisation and verbal processing of sessions. There were, however, several limitations to the study, including small sample size, lack of a dose-matched control group, and group assignment that was not fully randomized.

A number of considerations have been presented that suggest a role for music-induced affective responding in mediating positive therapeutic change. This may be accomplished through the use of music interventions that engage underlying neural reward networks, thereby serving to enhance intrinsic motivation, modulate arousal and mood, and promote social affiliation. These factors may in turn mitigate the effects of stress, and in particular depression, which can impede progress towards rehabilitative goals. Translating non-musical interventions into musical applications is central to The Transformational Design Model (TDM) [16, 18], which provides a guideline for developing targeted music interventions to address rehabilitative goals through a series of steps, involving assessment, goal setting, non-musical therapeutic exercise design, translation into therapeutic music interventions, and transfer to "real-world" applications.

Music Therapy Implications for Individuals Recovering from an ABI

Depression following a stroke has been referred to as "invisible wounds" [11], as people often do not realize or recognize when a person is experiencing depression. Researchers have noted music therapy may mitigate the effects of depression post-stroke, and propose that it is the result of providing patients with active music making opportunities housed in a therapeutic frame, which results in physical, aesthetic and relational experiences [52]. Emotions induced

by music may have a moderating impact on affective responding [30, 42, 46]. Unfortunately, many patients who recover from stroke may feel helpless and not experience pleasure or meaningfulness, which can subsequently negatively impact their self-concepts.

Active and standardized music therapy interventions including patient preferred music and NMT techniques (e.g. Therapeutic Instrumental Music Performance and MPC) may foster intrinsic motivation in patients' desire to participate and commit to their rehabilitation programs. Therapy can further influence and optimize the positive affective experience through the establishment of the therapeutic relationship [49-51]. By combining active music making with positive affective responding and therapeutic interaction, functional rehabilitative and psychotherapy goals that facilitate post-ABI, whole-person care may have the ultimate ability to be accomplished.

Future Directions and Conclusion

Evidence-based research cited above supports the notion that persons recovering from an ABI and experiencing depression may benefit from engaging in music therapy interventions. A 2017 Cochrane review [1] examining efficacy of music interventions for functional outcomes in persons with ABI in several domains, including gait, mood and emotions, cognitive functioning, social skills, activities of daily living, upper extremity function and pain, found that music interventions may improve gait, timing of upper extremity functional movement, quality of life and communication outcomes. However, while the results are encouraging, quality of evidence for the majority of studies is low, and the authors concluded insufficient to support recommendations for clinical practice.

The use of randomized controlled trials was found to be feasible in studying the effects of individual and group music therapy on persons with depression; however, a need for research of high methodological quality involving larger samples and blinding of assessors was identified [38]. Four of the five studies in the review [38] involved receptive as opposed to active treatment, indicating a requirement for more studies involving active music therapy interventions. The need for high-quality research into the effects of music therapy on persons with ABI, that will serve to inform clinical practice in multiple domains, is apparent.

References

1. Magee WL., Clark, I, Tamplin, J & Bradt, J. (2017). Music interventions for acquired brain injury: A review. *Cochrane Database Syst Rev.* 2017: 1. https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD006787.pub3/epdf/full
2. Krueger H. Koot J. Hall RE. O'Callaghan C. Bayley M. Corbett D. Prevalence of individuals experiencing the effects of stroke in Canada: Trends and projections. *Stroke.* 2015; 46(8), 2226-2231.
3. Rodgers, H. *Stroke*. In Barnes, MP. Good DC. eds, Handbook of Clinical Neurology; 2013: Vol. 110, 27-433. Retrieved from http://www.sciencedirect.com/science/handbooks/00729752/110.
4. Mallory BS. *Stroke.* In Cooper G. ed, Essential Physical Medicine and Rehabilitation. Totowa, NJ: Humana Press; 2006.
5. Paolucci S. Epidemiology and treatment of post-stroke depression. *Neuropsychiatr Dis Treat.* 2008; 4(1), 145-154.
6. Carr J. Shepherd R. Neurological Rehabilitation: Optimizing Motor Performance. Edinburgh, UK: Churchill Livingstone; 2010.
7. Salter K. Mehta S. Wiener J. Cotoi A. Teasell R. Foley N. et al. Post-stroke depression and mood disorders. 2018. In: Evidence-based review of stroke rehabilitation [Internet]. www.ebsr.com: [1-84]. Available from http://www.ebrsr.com/evidence-review/18-post-stroke-depression.
8. Dileo C. Bradt J. Medical Music Therapy: Evidence-based Principles and Practices. In I. Söderback I. ed, International Handbook of Occupational Therapy Interventions New York, NY: Springer; 2009: 445-451.
9. Bruscia KE. Defining Music Therapy 2nd ed. Gilsum, NH: Barcelona; 1998.
10. Ostir GV. Berges IM. Ottenbacher ME. Cow A. Ottenbacher KJ. Associations between positive emotion and recovery of functional status following stroke. *Psychosomatic Medicine.* 2008; 70(4): 404-409. doi: 10.1097/PSY.0b013e31816fd7d0.
11. Terry R. Invisible wounds: A survivor's perspective on the emotional challenges of recovery. *Stroke Connection 2010*; (May/June), 10-12. Retrieved from http://www.strokeassociation.org/STROKEORG/StrokeConnectionMagazine/ReadSCNow/SCM-MayJun-2010_UCM_313857_Article.jsp#.VuXLkvHUseM
12. Chrousos GP. Stress and disorders of the stress system. *Nature Reviews Endocrinology.* 2009; 5: 374-381.
13. Altenmüller E. Schlaug G. Music, Brain, and Health: Exploring Biological Foundations of Music's Health Effects. In MacDonald R, Kreutz G, Mitchell L, eds, Music, Health, & Wellbeing. Oxford, UK: Oxford University Press; 2012: 12-24.
14. Chanda ML. Levitin D.J. The neurochemistry of music. *Trends in Cognitive Sciences.* 2013; 17(4): 179-193.
15. Thaut MH. Wheeler BL. Music Therapy. In Juslin PN. Sloboda JA eds, Handbook of Music and Emotion: Theory, Research, Applications. Oxford, UK: Oxford University Press; 2010: 819-848.
16. Thaut MH. Rhythm, Music, and the Brain: Scientific Foundations and Clinical Applications. New York, NY: Routledge; 2005.
17. Wheeler BL. Music in Psychosocial Training and Counseling (MPC). In Thaut NH. Hoemberg V. eds, Handbook of Neurologic Music Therapy (pp. 331-359). Oxford, UK: Oxford University Press; 2014: 331-359.
18. Thaut MH. Hoemberg V. Handbook of Neurologic Music Therapy. Oxford, UK: Oxford University Press; 2014.
19. Street A. Combining functional and psychoanalytic techniques, using rhythmic auditory stimulation (RAS) and songwriting to treat a man with a traumatic brain injury. *Voices.* 2012; 12(3). Retrieved from https://voices.no/index.php/voices/article/view/673
20. Daveson BA. A description of a music therapy meta-model in neuro-disability and neuro-rehabilitation for use with children, adolescents and adults. *Australian Journal of Music Therapy.* 2008; 19, 70-85.
21. McGill University. *Whole person care*, 2012, Retrieved from http://www.mcgill.ca/wholepersoncare
22. Buonomano DV. Merzenich, MM. (1998). Cortical plasticity: From synapses to maps. *Annu Rev Neurosci.* 1998: 21, 149-186.
23. Poulsen, AA. Rodger S. Ziviani JM. Understanding children's motivation from a self-determination theoretical perspective: Implications for practice. *Aust Occup Ther J.* 2006; 53, 78-86.

24. McClelland D. Emotions as Indicators of Natural Incentives. In *Human Motivation*. Cambridge: Cambridge University Press: 1988, 107-129. Doi:10.1017/CBO9781139878289.006
25. Trainor LJ. Infant preferences for infant-directed versus non-infant-directed playsongs and lullabies. *Infant Behav Dev.* 1996; 19, 83-92.
26. Volkova A. Trehub S E. Schellenberg EG. Infants' memory for musical performances. *J Dev Sci.* 2006; 9(6), 583-589.
27. Trehub SE. Nakata T. Emotion and music in infancy. *Music Sci.* 2002; 37-61.
28. Corbeil M., Trehub SE, Peretz I. Singing delays the onset of infant distress. *Infancy*. 2015; 1-19. doi:10.1111/infa.12114
29. Phillips-Silver J. Trainor LJ. (2005). Feeling the beat: Movement influences infant rhythm perception. *Science.* 2005; 308, 1430.
30. Hunter PG. Schellenberg EG. Schimmack U. Feelings and perceptions of happiness and sadness induced by music: Similarities, differences, and mixed emotions. *Psychology of Aesthetics, Creativity, and the Arts.* 2010; 4(1), 47-56.
31. Saarikallio S. Music as emotional self-regulation throughout adulthood. *Psychol Music.* 2010; 39(3), 307-327.
32. Hunter PG. Schellenberg EG. & Griffith AT. Misery loves company: Mood-congruent emotional responding to music. *Emotion.* 2011; 11(5), 1068-1072.
33. Levitin DJ. Tirovolas AK. Current advances in the cognitive neuroscience of music. *Ann N Y Acad Sci.* 2009; 1156, 211-231.
34. Juslin PN. Liljeström S. Västfjäll D. Barradas G. Silva A. An experience sampling study of emotional reactions to music: Listener, music, and situation. *Emotion.* 2008; 8(5), 668-683.
35. Thompson WF. Schellenberg EG. Husain G. Arousal, mood and the Mozart effect. *American Psychological Society,* 2001; *12*(3), 248-251.
36. Schellenberg EG. Nakata T. Hunter PG. Tamoto S. Exposure to music and cognitive performance: tests of children and adults. *Psychol Music.* 2007; *35* (1), 5-19.
37. Schellenberg EG. Hallam S. (2005). Music listening and cognitive abilities in 10- and 11-year-olds: The Blur effect. *Ann N Y Acad Sci 1060. 2005*(1), 202-209.
38. Maratos A. Gold C. Wang X. Crawford MJ. Music therapy for depression (Review). *Cochrane Database Syst Rev.* 2009; (1), 1-20.
39. Kim DS. Park YG. Choi JH. Im SH. Jung KJ. Cha YA. Yoon YH. Effects of music therapy on mood in stroke patients. *Yonsei Med J,* 2011; 52(6), 977-981. doi:10.3349/ymj.2011.52.6.977
40. Särkämö T. Tervaniemi M. Laitinen S. Forsblom A. Soinila S. Mikkonen M. Hietanen M. Music listening enhances cognitive recovery and mood after middle cerebral artery stroke. *Brain.* 2008; 131(Pt 3), 866-876. doi:http://dx.doi.org/10.1093/brain/awn013
41. Goldstein A (1980) Thrills in response to music and other stimuli. *Physiol Psychol* 8:126–129
42. Blood AJ, Zatorre R J. Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences U. S. A.* 2001; 98(20): 11818-11823.
43. Koelsch S. Fritz T. Yves v. Cramon D. Müller K. Friederici AD. Investigating emotion with music: An fMRI study. *Hum Brain Mapp.* 2006; 27, 239-250.
44. Koelsch S. Towards a neural basis of music-evoked emotions. *Trends Cogn Sci.* 2010; 14(3), 131-137. Retrieved from http://www.cell.com/trends/cognitive-sciences/pdf/S1364-6613(10)00003-3.pdf
45. Mas-Herrero E. Zatorre RJ. Rodriguez-Fornells A. Marco-Pallares J. Dissociation between musical and monetary reward responses in specific musical anhedonia. *Curr Biol.* 2014; 24, 699-704.
46. Salimpoor VN. Benovoy M. Longo G. Cooperstock JR Zatorre RJ. The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS ONE.* 2009; 4(10), 1-14.
47. Hodges DA. *Psychophysiological Measures.* In Juslin PN, Sloboca, JA eds, Music and Emotion: Theory, Research, Applications Oxford, UK: Oxford University Press; 2012: 229-312.
48. Kreutz G. Quiroga Murcia C. Bongard S. (2012). *Psychoneuroendocrine Research on Music and Health: An overview.* In MacDonald R. Kreutz, G. Mitchell L. eds, Music, Health, & Wellbeing. Oxford, UK: Oxford University Press; 2012: 457-476.
49. Liljeström S. Juslin PN. Västfjäll D. Experimental evidence of the roles of music choice, social context, and listener personality in emotional reactions to music. *Psychol Music.* 2013; 41, 577-597.
50. Kirschner S. Tomasello M. Joint drumming: Social context facilitates synchronization in preschool children., *J Exp Child Psychol.* 2009; 102, 299-314.
51. Nayak S. Wheeler BL. Shiflett SC. Agostinelli S. Effect of music therapy on mood and social interaction among individuals with acute traumatic brain injury and stroke. *Rehabilitation Psychology*. 2000; 45(3), 274-283. doi:http://dx.doi.org/10.1037/0090-5550.45.3.274
52. Maratos A. Crawford MJ. Procter S. Music therapy for depression: it seems to work, but how?, *Br J Psychiatry.* 2011; 199, 92-93.

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