# Mending the Mind with Music:

# Physiological and Behavioural Exploration of Drops in Depression

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## Table of Contents

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# 1 Abstract

Music effectively alters emotions. Specifically, Drops (sudden deviations in music features, such as frequency, tempo and rhythm) influence prefrontal cortex (PFC) activity, emotions, working memory (WM) and depression. This novel research predicts; (1) repeated Drop apprehension over a two-week intervention would alter PFC activity, evoking positive emotions and emotional regulation to improve depression; (2) regular Drop listening would improve WM via PFC activity and decreased depression; (3) reduced depression and improved WM would remain one week after the intervention. Participants (N=19) screening for mild to severe depression, as measured by the Depression Anxiety Stress Scale (DASS-21), completed a two-week intervention of daily 30-minute music listening in Experimental (with Drops) or Control (without Drops) conditions. Participants also attended Pre-, Post-, and Follow-up laboratory sessions. In Pre- and Post-sessions continuous electroencephalogram (EEG) recorded brain activity during 20-second Drop clips, excitement ratings, and a WM task. The Follow-up session assessed longitudinal behavioural alterations in depression and WM one week after the intervention. Results demonstrated greater improved depression and positive emotion in the Experimental condition, but unchanging WM scores. Also, brain activity altered in several regions, including STG, SMG, IFG, ITG, PC, and, AG, but not the PFC as predicted. However, active areas are related to music processing, music-emotions, and depression. Thus, Drops have valuable potential as an intervention for emotional disorders including depression, but exact influences and limitations need further exploration.

**Keywords:** Drops, dance music, intervention, brain activity, EEG, music-emotions, depression, working memory

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## 2 Introduction

In recent years, mental health disorders have increasingly become a problem, with 43.4% of adults in the UK believing they have a disorder (Mental Health Foundation, 2016). Specifically, 19.5% of males and 33.7% of females have been professionally diagnosed with a mental health condition (Stansfeld et al., 2016). Furthermore, in 2015 almost 20% of those suffering from depression were young adults (aged 16-24, Office for National Statistics, 2017). Alarmingly, the number of suicidal thoughts within young adults has increased and is now higher than any other age group, alongside 41,921 hospitalisations for self-harm (McManus et al., 2016; Health and Social Care Information Centre, 2015, respectively). Depression also reduces recognition of emotions and motivation to partake in behaviour that advances mood, weakening social skills, creating a cycle of maladaptive behaviours, and decreasing patient's quality of life (Garrido & Schubert, 2015; Punkanen, Eerola, & Erkkilä, 2011). Thus, there is an irrefutable problem with depression, particularly in young adults.

Additionally, current treatments for mental health disorders are often inadequate, inaccessible and ineffective (Carta et al., 2013; Mago, Fagiolini, Weiller, & Weiss, 2018; Tracy, Joyce, & Shergill, 2016). With current rates of depression expected to increase significantly and with present forms of treatment lacking efficiency and accessibility, there is an undeniable need for more effective and reachable forms of treatment (Mental Health Foundation, 2016; McCrone, Dhanasiri, Patel, Knapp, Lawton-Smith 2008). This research aims to address the problems with current depression treatments by investigating whether dance music, specifically Drops; a moment of variation in music features such as rhythm, tone, frequency, pace, beat, tempo, bass and amplitude, can be used as a beneficial and accessible instrument to aid depression (Turrell, Halpern, & Javadi, in preparation).

In this review, music's association with numerous emotions, particularly powerful, positive emotions will be assessed. Also, music's potential as a form of music therapy (MT), due to its unique ability to evoke emotions is reviewed. After, music, music-emotions and brain activity research is collaborated, indicating neurological evidence for an emotive music effect. Last, will be the assessment of how deviations in music induce emotions and prefrontal cortex

(PFC) activity, leading to the hypothesis that distinctly deviating music moments ‘Drops’ increase PFC activity, emotional responses, and MT potential.

## 2.1 Music and Emotion

It has long been established that music has a significant role in human life, culture and society (Habibi & Damasio, 2014; Nagel & Bradshaw, 2013). Music is commonly apprehended in everyday life, with individuals listening to music for the powerful and reliable emotions it elicits (Koelsch, 2014; Sloboda, O'Neill, & Ivaldi, 2001). Numerous influential and consistent emotive effects have been associated with music across people; including the elicitation of happiness, fear, anger, anticipation and excitement (Habibi & Damasio, 2014; Koelsch et al., 2013; Gosselin et al., 2005; Grynberg, Davydov, Vermeulen, & Luminet, 2012; Tabatabaie et al., 2014, respectively).

In fact, research suggests that music possesses a human evolutionary basis, enabling the evocation of positive feelings via ‘social emotions’, which lead to coordination, discord and harmony (Panksepp, 2009). This is further implied by people using music every day across cultures to not only elicit various emotions, but also regulate, modify and release emotions (Luck, 2014; Omigie, 2016). Such beneficial effects of music on regulation can even be achieved when listeners are not attending to the music (Bogert et al., 2016). Thus, music can conjure influential positive emotions just through the apprehension of personally liked and elevating songs (Bray, Oliver, Graham, & Ginis, 2013).

Furthermore, specific genres of music relate to particular emotions. For instance, Bhatti, Majid, Anwar and Khan (2016) investigated emotive responses (such as happy, anger, love and sadness) to a range of music genres including rap, hip-hop, electronic, metal and rock. They showed rap music significantly related to sadness, whilst rock music associated with happiness. This implies reliable music-evoked emotions to distinct music genres. However, music is complex in its structure, evoked emotions, and interactions with people, suggesting elicited emotions differ between individual listeners which makes predicting emotional responses difficult (Daly et al., 2015).

Meanwhile, ambiguous emotional responses to music could result from oversimplified emotion categorisations. Research often adopts simple emotion labels such as sadness, happiness, anger, fear, etc. Some researchers suggest that music-induced emotions are more complicated than simple pleasant or unpleasant groupings, terming them ‘music-emotions’ (Trost, Ethofer, Zentner, & Vuilleumier, 2012). Similarly, other research implies that music has a unique ability in humans to evoke strong and intricate emotions, such as peacefulness, wonder and nostalgia (Omigie, 2016). Therefore, the complexity and inaccuracy of predicting emotive responses to music is partly due to the common use of simplistic emotive labels.

In addition, the uniqueness of music and its elicited emotions are debated. Some researchers suggest music's ability to elicit powerful emotive responses is not independent to music and other art forms, such as paintings, can evoke similar emotions but in alternative ways (Miu, Piţur, & Szentágotai-Tătar, 2016). Also, music-evoked emotions occur via mechanisms that are not unique to music, such as brain stem reflexes, expectancy and episodic memory, suggesting underlying music-emotion functions are present in other forms of emotion elicitation (Juslin & Västfjäll, 2008).

Although, other research implies music does uniquely induce and control emotional responses. Randall, Rickard and Vella-Brodrick (2014) suggested music is used independently for regulating emotional resources to attain goals. Also, the emotive influence of music is additive to other stimuli, such as films, pictures and the semantic meaning of lyrics (Ellis, & Simons, 2005; Baumgartner, Esslen, & Jäncke, 2006; Mori & Iwanaga, 2014, respectively). Thus, music also appears to distinctively and powerfully influence emotions, causing uncertainty on music's unique emotive influence.

Regardless, ambiguity of how music induces emotions also impacts conclusions on the exclusiveness of music-evoked emotions. For instance, music has an instant and continuous influence on emotion, implying musical features such as pitch, tempo, key and rhythm directly elicit emotional responses (Kerer et al., 2014; Komosinski & Mensfelt, 2016). However, other research suggests music elicits emotions indirectly via mediators, such as metaphors and implied external meanings (Konečni, 2008; Pannese, Rappaz, & Grandjean, 2016). This enables inconsistencies such as the negative emotion paradox, where negative music-emotions are experienced positively by listeners (Schubert, 2016). Thus, it is unclear whether music directly influences emotion or if this occurs via the mediation of factors, such as metaphors and societal context.

Moreover, emotional state prior music apprehension influences music-evoked emotions. For example, several studies indicate feelings experienced before hearing music pieces can influence emotional responses. Taylor and Friedman (2014) showed participants who felt disgusted before hearing a musical segment had an increased inclination to listen to happy music, compared to none disgusted participants. Also, preceding feelings of happiness and sadness are associated with increased experiences of pleasure or ‘chills’ in music (Nusbaum et al., 2014). Thus, individual prior emotional states affect the music types people listen to and the extent of emotional responses, raising uncertainty whether music elicits emotions or emotions impact music listening behaviours.

Additionally, external factors, such environment and situations, when apprehending music can influence the type and extent of emotions evoked. For example, Egermann et al. (2011) showed people experiencing heightened positive emotion and physiological arousal when acquiring music alone as compared to within groups. This suggests music is more arousing and emotive when experienced alone than in social situations. Perhaps, due to the absence of social distractions and increased concentration when apprehending music alone (Egermann et al., 2011). Therefore, music evokes strong emotions, however outside influences can enhance or decrease these emotive effects.

Nevertheless, one central mechanism influencing music-evoked emotions is expectancy. Research suggests that deviations from expectations in music increase arousal, tension and emotion (Koelsch, 2014; Lehne, Rohrmeier, & Koelsch, 2014; Mikutta, Altorfer, Strik, & Koenig, 2012; Zentner, Grandjean, & Scherer, 2008). Music content and structure leads to expectations for the progression of a song within listeners (Tillmann, Poulin-Charronnat, & Bigand, 2014). Tillmann et al. (2014) suggested musical expectations predominantly form music cognition and music-induced emotions, which depend on the execution of expectancies. Also, unexpected alterations in music are fundamental to the elicitation of strong emotions (Arjmand, Hohagen, Paton, & Rickard, 2017). It is shown that unanticipated deviations in musical features, such as pitch, tempo, intensity and texture, increase tension and anticipation, resulting in extreme emotions (Arjmand et al., 2017). Thus, musical expectations, particularly unexpected musical feature alterations, are important for positive music-induced emotions (Omigie, 2016).

## 2.2 Music Intervention

Music can be beneficial in numerous forms of interventions from treating disorders of consciousness, child development, anxiety and stress in pregnancy, to improving emotion in hospital patients (Grimm & Kreutz, 2018; Dumont, Syurina, Feron, & van Hooren, 2017; Corbijn van Willenswaard et al., 2017; Iyendo, 2016, respectively). For example, short-term interventions with focus on how music elicited emotions improved emotional recognition in vocals (Mualem & Lavidor, 2015). Music is also beneficial in incidences of aphasia, prematurity, stroke, anger management, hemispatial neglect, and autism (Leonardi et al., 2018; Palazzi, Nunes, & Piccinini, 2018; Grau-Sánchez, Ramos, Duarte, Särkämö, & Rodríguez-Fornells, 2017; Hakvoort, Bogaerts, Thaut, & Spreen, 2015; Klinke, Hafsteinsdóttir, Hjaltason, & Jónsdóttir, 2015; Bieleninik et al., 2017, respectively). Therefore, music's ability in inducing and understanding emotions may be advantageous across aspects of comprehending and improving everyday lives.

Additionally, music is implemented in everyday lives due to its unique individual influence and ability to produce predictable and effective emotions. For instance, over 69% of young adults use music to manage emotions after loss (ter Bogt, Vieno, Doornwaard, Pastore, & van den Eijnden, 2017). Also, music is applied more often for consolation in females, those with lower aggression and higher depression and/or anxiety, and those who prefer chart music; a selection of music that is popular and listened to by the majority of a population (Achterberg, Heilbron, Houtman, & Aupers, 2011). These individuals were more likely to report an intense emotional music reaction and found it helpful due to texture, lyrical meanings, and anticipated closeness to artists or other listeners. Thus, music is already utilised by young adults to regulate strong negative emotions, such as loss.

Furthermore, music treatments using pleasant melodies have been successfully developed for numerous disorders such as dementia, schizophrenia, depression, obsessive-compulsive disorder (OCD), and stress (Kavak, Ünal, & Yılmaz, 2016; Kayashima et al., 2017; Lee, Jeong, Yim, & Jeon, 2016b; Spiro, Farrant, & Pavlicevic, 2017; Zhao, Bai, Bo, & Chi, 2016). McCaffrey & Edwards (2016) imply that MT offers a world saturated with musical sound, allowing for humanity and improvements in an array of disorders. Therefore, MT and human interaction with music have the capacity to aid in many mental health disorders, emphasising its potential as an efficient and extensive form of therapy.

Also, music can evaluate impaired emotion recognition in neuronal disorders, such as Parkinson's disease. Patients with Parkinson's disease exhibit decreased recognition of anger and fear in music, but not sadness and happiness as compared to controls (van Tricht, Smeding, Speelman, & Schmand, 2010). Thus, Parkinson's patients are less able to identify complex emotions induced by music, suggesting a deficit in emotional processing which can negatively impact social functioning (Schwartz & Pell, 2017; Wasser at al., 2018). Therefore, music can also be advantageous to treatments through the assessment of co-morbid emotional deficits.

Additionally, music can be applied to reducing symptoms of mental health disorders. For instance, MT alongside standard treatment in individuals with OCD helped decrease the presentation of symptoms, such as checking behaviours and slowness (Shiranibidabadi & Mehryar, 2015). This implies MT can aid the treatment and reduction of symptoms in disorders like OCD. Though, not all symptoms of OCD improved; washing and responsibility behaviours remained constant (Shiranibidabadi & Mehryar, 2015). Thus, MT is an effective, none-pharmacological treatment for several symptoms of disorders like OCD but is limited.

Regardless, MT is more beneficial than other non-pharmacological treatments. For instance, MT over four weeks increased longitudinal benefits on emotional states in those with Alzheimer's disease, as compared to a cooking intervention (Clément, Tonini, Khatir, Schiaratura, & Samson, 2012). Those in MT showed elevated long-term emotional well-being than patients who participated in cooking sessions. This implies MT is helpful in the treatment of complex disorders like Alzheimer's, more so than other forms of creative therapies (Clément et al., 2012). Thus, MT elicits longitudinal advantages for emotional states in stressful and life-changing illnesses.

Also, music has already been administered in the treatment of depression. Previous studies have shown MT, alongside cognitive behavioural therapy (CBT) and standard treatment, reduces symptoms and improves the overall rehabilitation of depression (Erkkilä et al., 2011; Fachner, Gold, & Erkkilä, 2013; Trimmer, Tyo, & Naeem, 2016; Zhao et al., 2016). For example, individual MT alongside standard treatment is effective at reducing depression and anxiety and increasing general functioning up to 3 months post-treatment (Erkkilä et al., 2011; Fachner et al., 2013). In fact, Silverman (2016) implied that one session of educational MT including song writing and lyric analysis could improve expressions of hope in patients, decreasing symptoms of depression.

Furthermore, music can be used in the diagnosis of mental health disorders, such as depression. Punkanen, Eerola and Erkkilä (2011) suggest individuals with depression possess a negative emotional bias to music-induced emotions, the level of which dependent on depression severity, alexithymia or anxiety. Biases were assessed using 9-point Likert measures for the emotions anger, sadness, tenderness, fear, and happiness. Those with increased depression regarded music-emotions more negatively, with elevated ratings for sadness and fear and reduced scores for happiness and tenderness. Thus, identification of biases via music-emotions could be useful to classify mental health disorders such as depression and their severity.

Nevertheless, music is not always advantageous in the treatment of disorders, such as depression, suggesting there are optimal forms of MT. For example, patients must be engaged in MT, taking an active role in sessions, contexts and relationships involved. If patients are not motivated and committed then MT will not reduce depressive symptoms (Rolvsjord, 2015). However, this weakness is not unique to MT; a minimal level of active and dedicated patient engagement is required for many forms of effective treatment (Chu, Suveg, Creed, & Kendall, 2010).

In addition, MT should be developed to enable optimal benefits for patients. For instance, research demonstrates the most effective MT's in depression and anxiety contain 20 or more sessions (Chen, Leith, Aarø, Manger, & Gold, 2016). This number of sessions is argued to allow more beneficial treatment, promoting self-esteem and social functioning in patients (Chen et al., 2016). Thus, when developing and evaluating MT's effectiveness in disorders like depression, it is important to consider intervention and experiment designs.

Furthermore, patient age can impact MT's efficiency and ability to improve maladaptive emotional behaviour. Research suggests that MT is most effective when applied to working aged people (Erkkilä et al., 2011). Moreover, patient age impacts the most beneficial form of therapy. Younger adults improve more in group MT, whilst older adults find self-directed MT most advantageous (Gold, Saarikallio, Crooke, & McFerran, 2017). This may result from generational alterations in music's importance and uses, such as adolescence forming identities and adults reminiscing through music (Gold et al., 2017; Nune Nikoghosyan, 2014). However, research also suggests that music is used similarly across generations (Haenfler, 2014; Nune Nikoghosyan, 2014). Thus, it is unclear how age influences MT's effectiveness.

Nevertheless, depression also associates with increased liking of sad music, despite unhealthy consequences (Garrido & Schubert, 2015). Huron (2011) suggests that music-induced sadness elevates the hormone prolactin, which increases liking of sad music. Also, higher depression predicts augmented enjoyment of sad music in women and particularly men (Hogue, Crimmins, & Kahn, 2016). Individuals with depression exhibit dysfunctional attitudes following induced sadness and not all music use is helpful, as patients are orientated towards the maladaptive use of sad music (Van der Does, 2002). Thought should then be placed on the type of music used in MT and ways to alter patients' dysfunctional listening behaviours.

Despite this, MT's main advantage is its ability to improve numerous disorders and co-morbid problems. Often mental health difficulties co-occur within conditions, such as OCD, Parkinson's, Alzheimer's and stroke, resulting in accompanying depression, anxiety and stress (Vorstenbosch & Laposa, 2015; Troeung, Gasson, & Egan, 2015; Marchant & Howard, 2015; Grajny et al., 2016, respectively). MT possesses the unique capability of improving symptoms of main diseases and co-occurring disorders when used alongside standard care (Gardstrom, Bartkowski, Willenbrink, & Diestelkamp, 2013; Pedersen, Andersen, Lugo, Andreassen, & Sütterlin, 2017; Shiranibidabadi & Mehryar, 2015; Zhao et al., 2016). Through reducing co-occurring mental health conditions, motivation to attend standard therapy is enhanced, improving the overall rehabilitation of disorders, such as stroke (Maclean, Pound, Wolfe, & Rudd, 2000).

In addition, poor working memory (WM), episodic memory and executive functioning are common accompanying concerns in mental health conditions like depression (Bianchi & Laurent 2016; Szczygieł & Maruszewski, 2015; Shan et al., 2018; Sankar, Adams, Costafreda, Marangell, & Fu, 2017; Jayaweera et al., 2016; Zahodne, & Tremont, 2013, respectively). For example, those with depression exhibit enhanced memory for negative occurrences, but reduced memory for positive events (Dillon & Pizzagalli 2018). Thus, there is a link between mental health disorders and reduced WM, suggesting MT can be effective in improving both.

Furthermore, MT induces similar longitudinal brain activity to depression and memory problems. For example, MT relates to alterations in the frontal cortex, amygdala, hippocampus, right temporoperietal alpha and left-sided brain activity for up to 3 months (Fachner et al., 2013; Hou et al., 2017; Lee, Han, & Park, 2016a; Misuraca, Miceli, & Teuscher, 2017; Vik, Skeie, Vikane, & Specht, 2018). This transfers into the reduction of depression symptoms and its co-problems in memory, emotion and cognitive functions through regulation in fronto-temporal brain regions (Lee et al., 2016a; Hou et al., 2017; Leonardi et al., 2018, respectively). Thus, depression impacts patterns of brain activity, emotions and memory, which can all be improved in the long term with MT.

### 2.3 Music, Emotions and the Brain

Understanding how music influences brain activity is essential for optimising MT benefits in mental health disorders. Music undoubtedly evokes emotions, but how and the predictably of effects are ambiguous. Previous research has shown music to reliably influence brain regions in subcortical areas associated with mediating emotions, auditory and motor processes, as well as regions related to life regulation (Panksepp, 2009; Habibi & Damasio, 2014, respectively). More than 20% of variance in music-elicited emotions can be predicted using brain activity combined with musical features (Daly et al., 2015). Thus, comprehending the neurology of music-induced emotion is essential to understanding human emotion and music's uses in aiding several disorders, such as depression (Koelsch, 2014).

Prior literature demonstrates music's association with neuronal activity in several brain regions, including; the hypothalamus, amygdala, nucleus accumbens, insula, thalamic limbic cortex, hippocampus, upper brainstem nuclei, frontal cortex, frontoparietal cortex, orbitofrontal cortex (OFC), and cingulate cortex (Bogert et al., 2016; Habibi & Damasio, 2014; Koelsch, 2014; Moore, 2013; Omigie, 2016; Rogenmoser, Zollinger, Elmer, & Jäncke, 2016). Thus, an extensive breadth of brain areas are associated with the apprehension of music and specific, powerful music-evoked emotions.

Furthermore, music apprehension is related to varying oscillations in the brain, implying alternative neuronal activity when apprehending different emotive music. For instance, Arjmand et al. (2017) showed peaked frontal asymmetry in frontal brain areas at moments of key musical changes. This suggests that variations in musical features lead to significant and quick neuronal alterations in frontal brain regions. Also, research shows larger alpha-power density in participants listening to music rather than only viewing pictures, as music elicits emotional and arousing brain networks, involving the parietal, frontal, occipital and temporal regions (Baumgartner et al., 2006) Thus, music increases oscillations in brain areas previously related to music-induced emotions, emphasising music's emotive influence. Although, individual subjective feelings can influence the brain activity music evokes, suggesting oscillations may also be a consequence of prior participant emotions (Kayashima et al., 2017).

Also noteworthy, is the established connection between physiological responses, such as heart rate, brain activity, arousal and emotion (Huron, 2006; Scherer & Zentner, 2001). Brain regions such as the ventromedial prefrontal cortex and the amygdala have previously been associated with heart rate variability and physiological changes which are objective measures of emotions (Huron, 2006; Scherer & Zentner, 2001; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). This suggests that brain activity alongside physiological alterations in heart rate indicate music's effective impact on emotions.

Meanwhile, research also extensively explores music-emotions via valence and arousal (Egermann, Fernando, Chuen, & McAdams, 2015; Sandstrom & Russo, 2010; Wheeler, Sokhadze, Baruth, Behrens, & Quinn, 2011). Both valence and arousal are associated with alternative regions of brain activity. Valence relates to activity in the frontal lobes, ventromedial prefrontal cortex, ventral posterior parietal cortex, frontal inter-hemisphere connectivity, and decreased parietal bilateral connectivity (Dolcos, LaBar, & Cabeza, 2004; Greene, Flannery, & Soto, 2014; Heller, 1993; Rogenmoser et al., 2016; Shahabi & Moghimi, 2016). Whilst, arousal is linked to right parieto-temporal region, decreased alpha frequency, dorsal posterior parietal cortex, posterior cingulate, and dorsomedial prefrontal cortex activity (Dolcos et al., 2004; Greene et al., 2014; Rogenmoser et al., 2016; Shahabi & Moghimi, 2016). Therefore, valence and arousal are evoked differently within music, suggested by the alternative brain regions elicited. However, interaction between valence and arousal is also present and associates with activity in the left ventral posterior parietal cortex (Greene et al., 2014), increasing ambiguity as to whether they are separate functions.

Nonetheless, valence and arousal are associated with numerous emotions and corresponding patterns of brain activity. For example, high arousing positive emotions relate to activity in motor and sensory brain areas, the insula and the left striatum; whereas low arousing positive emotions accompany activity in the hippocampus, right striatum, OFC, and ventromedial prefrontal cortex (Trost et al., 2012). Thus, alternative patterns of brain activity (including those linked to memory, reward behaviour, sensorimotor processes, and self-reflective functions) are evoked depending on the combination of musical features, arousal, valence, and induced emotions (Trost et al., 2012). However, double dissociations indicate that music-evoked emotions are independent, as emotional impairment can occur without impediment to arousal and valence judgements (Khalfa et al., 2008).

Additionally, research indicates brain areas associated with processing music-induced emotions. For instance, acknowledgement of emotion in music relates to neuronal activity in the frontal lobe. Omar et al. (2011) demonstrated that frontotemporal lobar degeneration (FTLD) leads to reduced grey matter within brain areas such as the medial prefrontal cortex, amygdala, insula, subcortical mesolimbic system and OFC. This results in the impaired recognition of music-emotions, including anger, sadness, fear and happiness, suggesting the importance of frontal brain regions in processing music-emotions. However, FTLD does not only decrease recognition of emotion in music, but also in voices and faces, suggesting music-emotions are not unique to music (Omar et al., 2011).

Furthermore, cognitive states when processing music alters active brain regions for music-elicited emotions. When music-emotions are assessed explicitly (focused attention on emotions experienced) there is increased activity in prefrontal, cortical, dorsomedial and occipital brain areas. Meanwhile, music-emotions processed implicitly (participants are unaware of examining emotions) showed increased brain activity in the dorsolateral prefrontal cortex (DLPFC), frontoparietal cortex and striatal regions (Bogert et al., 2016). Therefore, whether emotion in music is assessed implicitly or explicitly influences corresponding brain activity.

Also, forms of music-emotions elicited influences associated brain areas. For example, music inducing happiness relates with increased brain activity in areas including; the parahippocampal gyrus, anterior cingulate, bilateral auditory cortex, and the ventral and dorsal striatum (Bogert et al., 2016; Mitterschiffthaler, Fu, Dalton, Andrew, & Williams, 2007). Meanwhile, sadness and/or fear in music associates with activity alterations in brain regions such as the OFC, amygdala, middle frontal gyrus, hippocampus, anterior cingulate, and auditory association areas (Bogert et al., 2016; Mitterschiffthaler et al., 2007). Therefore, alternative patterns of brain activity appear from different music-induced emotions.

Such associations between emotions elicited and particular brain activity has been elaborated with the use of neuroimaging techniques. For example, Mitterschiffthaler et al. (2007) demonstrated active brain areas during happy and sad music. Brain activity was shown in the anterior cingulate relevant for targeting attention, the dorsal and ventral striatum utilised in movement and reward experiences, and medial temporal areas implicated in music appraisal and emotion processing. Thus, using neuroimaging techniques, such as electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI) enables a clearer understanding of music-elicited emotions, allowing music emotional responses to be better predicted (Daly et al., 2015).

Furthermore, research expands on the relationship between specific brain activity and music-evoked emotions through brain damage, particularly musical anhedonia; a specific dysfunction of positive emotion in music (Belfi, Evans, Heskje, Bruss, & Tranel, 2017). A man with a right inferior parietal lobe lesion displayed musical anhedonia, resulting in impaired emotional responses to music but leaving other cognitive functions such as memory, speech, perception and recognition intact (Satoh, Nakase, Nagata, & Tomimoto, 2011). This suggests that right inferior parietal lobe damage selectively impedes emotional experiences in music, meaning music-emotions relate to unique brain networks, including the parietal lobe.

Therefore, music has a separable, powerful and unique emotive effect on listeners and their corresponding brain activity.

Another extensively explored mechanism of music-emotions and related brain activity is musical expectancy (Huron, 2006; Meyer, 1956; Omigie, Pearce, Williamson, & Stewart, 2013). Unexpected moments in music permit powerful emotions and associates with specific brain activity within listeners. For example, musical expectancy relates to increased neuronal activity in the amygdala, basal ganglia, OFC, and nucleus accumbens (Koelsch, Fritz, & Schlaug, 2008; Lehne et al., 2014; Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011; Salimpoor et al., 2013). Also, music expectancy relates to greater physiological arousal in skin conductance, heart rate, and blood volume (Egermann & McAdams, 2013; Steinbeis, Koelsch, & Sloboda, 2006). Both music expectancy and mentioned brain regions correlate with emotions such as satisfaction, surprise and frustration (Omigie, 2016) Thus, music expectancy is fundamental to the experience of strong music-emotions and significant neuronal activity in relevant brain areas.

Additionally, several brain regions during unexpected alterations in music are associated with ‘chills’; experiences of strong positive emotions and reward (Arjmand et al., 2017; Blood, Zatorre, Bermudez, & Evans, 1999; Panksepp, 1995; Salimpoor et al., 2011; Zentner et al., 2008). These include; the caudate nucleus, nucleus accumbens, amygdala, DLPFC and OFC (Klineburger & Harrison, 2015; Koelsch, Fritz, Cramon, Müller, & Friederici, 2006; Koelsch et al., 2008; Salimpoor et al., 2011). Thus, specific brain areas have been associated with powerful positive emotions and physiological responses in unexpected musical moments.

Consider the OFC and its importance in determining and experiencing music-induced emotions. Research has shown OFC activity is predictable in everyday music listening across genres (Alluri et al., 2013). Also, the OFC is influential in aesthetic assessments and self-focussing evaluations of individually acquired music (Alluri et al., 2013). This suggests the OFC is essential to experiencing music-emotions and is unconsciously active during the personal apprehension of music.

Furthermore, the OFC is fundamental to the experience of positive and pleasurable music-emotions (Greene et al., 2014; Li, Chen, & Tsai, 2015). Previous research suggested the link between OFC activity and pleasant emotions is mediated by music expectancy. For example, Lehne et al. (2014) acknowledge expectancy, tension and prediction in music as mediators of music-evoked emotions. They suggest musical structure enables tension, which elicits activity in the left lateral OFC, inferior frontal gyrus, and right superficial amygdala. Also, unexpected deviations in music relate to increased OFC and amygdala activity, which associate with elevated reports of emotions and musical tension (Mikutta et al., 2015). Thus, the OFC is central to experiencing music-emotions that are induce by moments of musical tension and deviation.

Additionally, positive feelings such as reward, are shown to be elicited by numerous visual and musical art forms (Li et al., 2015). Li et al. (2015) propose reward is divided into three aspects; anticipation, gain and loss. Different brain regions have been associated with these alternative phases of reward. For example, anticipation associates with bilateral temporoparietal junction and left-biased lateral OFC activity. Meanwhile, gain is related to activity in left temporoparietal junction and medial OFC regions. Lastly, loss is linked to activity in the right temporoparietal junction. Thus, OFC activity is important in the positive aspects of reward; anticipation and gain. This further emphasises tension and anticipation in music relating to activity in the OFC and mediating positive music-emotions.

Moreover, the OFC is fundamental in cognitive abilities, such as memory (Schnider, 2013; Zimmermann, Li, Rainnie, Ressler, & Gourley, 2018). Vik et al. (2018) conducted an eight-week music intervention with mild traumatic brain injury patients. The intervention consisted of piano lessons and fMRI before and after the eight-week period. Results showed the therapy effected neuroplastic alterations in the OFC, which associated with cognitive improvements in attention, memory and social interactions. In fact, developments in patient's cognitive abilities increased to the extent that 90% were able to return to work post intervention. Therefore, music can induce alterations in OFC functioning after brain damage, which enables improvement in emotions and cognitive abilities, such as memory.

Another brain area shown to be essential for music processing, but less relevant to music-emotions, is the supramarginal gyrus (SMG). The SMG is used in the processing of music pitch and has a causal influence on pitch memory (Schaal, Williamson, & Banissy, 2013; Schaal et al., 2015a; Schaal et al., 2015b). For instance, anodal and repetitive transcranial magnetic stimulation (TMS) to the left SMG during pitch retention lead to increases in pitch detection reactions times (Schaal et al., 2013; Schaal et al., 2015b). In addition, cathodal TMS to the left SMG decreases recognition and recall in pitch memory (Schaal et al., 2015a). Thus, the left SMG has an explicit role in the retention and maintenance of pitch memory in music. Although, this impeding influence of cathodal stimulation only influenced musicians when it occurred in the right SMG, suggesting musical pitch is detected differently between musicians and non-musicians (Schaal et al., 2015a).

Furthermore, the ability to perceive absolute pitch (AP) in music is associated with structural differences within the SMG. Dohn et al. (2015) explored brain variances between musicians who were able to detect AP and those who were not. They demonstrated increased cortical thickness in the bilateral superior temporal gyrus, right SMG, and left inferior frontal gyrus accompanied the ability to perceive AP. This further implies the SMG is important for pitch perception and the most accurate form of pith identification (AP) relates to increased SMG activity.

Also, the SMG is utilised in the detection of deviances in music. Research has shown alternative deviations in music; whether they are apparent with noticeable off-key alterations or less apparent with unclear in-key changes, relate to different brain activity. For example, apparent deviations relate to neurological activity in the premotor, inferior frontal, and anterior insula areas. Whilst, more subtle deviations associate with activity in premotor and inferior frontal cortices, anterior insula, superior temporal gyrus and SMG (Wehrum et al., 2011). This implies the SMG detects smaller, more subtle deviances in music. Although, SMG activity for small music deviances was only found within musically trained children, meaning SMG activity may not be present for all music listeners.

In addition, another brain region important in processing music features is the superior temporal gyrus (STG), specifically the right STG (rSTG). Research has demonstrated that the rSTG is employed in music processing and is more active for music than other acoustic sounds, such as language (Altenmüller, Siggel, Mohammadi, Samii, & Münte, 2014; Angulo-Perkins et al., 2014; Seger et al., 2013). Furthermore, musicians with greater training and musical exposure display increased rSTG activity, despite bilateral STG activity not differing between musical training or musical genres (Angulo-Perkins et al., 2014). This implies the rSTG is specific to the processing of musical sound.

Furthermore, evidence from structural brain alterations suggests the STG is essential to processing music. For instance, research shows increased grey matter within the STG for musicians compared to non-musicians, implying musical training induces brain plasticity that alters STG structure (Fauvel et al., 2014). Also, exploration into the brain structure of those who cannot process music (Amusia) has found irregular grey matter volumes within the rSTG

(Albouy et al., 2014). Thus, the STG, particularly the rSTG, has a central role in music processing and understanding.

In fact, research has demonstrated the specific roles of music processing involving the rSTG. For example, the rSTG is used in the assessment of music melodies, imagery, pitch and unexpected deviations (Ellis et al., 2012; Herholz, Halpern, & Zatorre, 2012; Nan & Friederici, 2013, Seger et al., 2013, respectively). Researchers found that violations to melodies, regular exclusions to expected music tones and the identification of such deviations relates to increased activity within STG and rSTG (Lappe, Steinsträter, & Pantev, 2013; Ono, Altmann, Matsuhashi, Mima, & Fukuyama, 2015). Therefore, the STG, specifically the rSTG, is essential to music processing and detecting music deviations.

Meanwhile, an additional brain area useful in the processing of musical features such as rhythm and sound sequences, as well as deviations and alterations in pitch is the DLPFC (Doeller et al., 2003; Koelsch & Siebel, 2005; Platel et al., 1997). The DLPFC associates with higher cognitive processing for several functions and is referred to as the brain 'hub' (Buckner et al., 2009). In music, the DLPFC is important for improvisation and processing complex, positive emotions, such as transcendence (Beaty, 2015; Koelsch et al., 2006; Omigie, 2016, respectively). Thus, the DLPFC is central to numerous high functioning music processes, including the elicitation of positive emotions.

However, the DLPFC is not active for all forms of music. For example, Bigliassi, León-Domínguez and Altimari (2015) showed DLPFC activity during the apprehension of classical music but not techno music. Increased heart rate variability for classical music also indicated elevated physiological arousal to classical music but not techno music. This implies greater DLPFC activity relates to increased physiological arousal, suggesting elevated excitement but not for all musical genres.

On a different note, research has established a relation between emotions, brain activity and WM, including the DLPFC and OFC within the PFC (Alloway & Horton, 2016; Bechara, Damasio, & Damasio, 2000; Deckersbach et al., 2008; Smith et al., 2018). For instance, elevated DLPFC activity increased positive emotion, emotion regulation and memory of pictures (Dolcos et al., 2004; Moore, 2013). Also, irregularities in the DLPFC link to alterations in WM functioning, suggesting the DLPFC is central to high cognitive processes like WM (Deckersbach et al., 2008). Likewise, OFC activity relates to WM and activity increases in response to regulating emotional distractions (García, Garcés, del Río, &

Maestú, 2017). Additionally, the PFC is associated with emotional regulation, which has been considered a form of WM (Sieb, 2013). Thus, there is a clear association between emotion, the PFC, and WM ability.

Research also suggests enhanced WM can aid depression by allocating more attention to positive stimuli and breaking negative biases (Alloway & Horton, 2016). Patients with remitted depression demonstrate abnormal activity within the PFC in response to negative emotions and demanding WM tasks (Kerestes et al., 2012). Meanwhile, OFC and DLPFC activity is negatively moderated by adverse emotions, debilitating WM in obsessive compulsive disorder (OCD; Han et al., 2016). Therefore, brain regions associated with positive music-evoked emotions and effective disorders, are also apparent in WM and can interact to enhance or hinder WM ability.

One way in which WM can be assessed is via tests such as, the N-Back and Counting Span Tasks (Conway et al., 2005; Soveri, Antfolk, Karlsson, Salo, & Laine, 2017). Previous research suggests that other WM tasks, including the n-back test, are demanding and require different degrees of cognition, whilst the Counting Span Task may be an easier though reliable and valid WM measure (Conway et al., 2005: Soveri et al., 2017). Also, the Counting Span Task has been utilised repeatedly in previous literature to assess WM in depression, demonstrating its appropriateness in this sample (Conway et al., 2005). Thus, the Counting Span Task was used as an assessment of WM ability before and after the intervention, due to its less challenging, yet reliable and valid WM measurement.

Meanwhile, a unique moment of music referred to as the Drop is associated with positive emotion and specific prefrontal cortex (PFC) activity (Turrell et al., in preparation). In fact, Drop apprehension induces strong neuronal activity in four regions; SMG, STG, DLPFC, and OFC (Turrell at al., in preparation). Increased OFC activity was seen during whole Drop apprehension, suggesting its importance in processing musical expectancy and tension, as well as experiencing co-occurring positive emotions. Also, activity in the DLPFC and SMG was seen post-Drop, implying they are fundamental in processing deviations in music. Lastly, the STG was active during pre-Drop, indicating its use in processing music features as they build tension. It is argued that the unique structure of Drops allows for unexpected sections of music, which induces specific PFC activity, heightens physiological arousal (heart rate) and increases ratings of excitement (Turrell et al., in preparation).

### 2.4 Aims and Hypotheses

Overall, there is a definitive association between the PFC, emotional regulation, memory and MT. Here Drops will be utilised to explore the effect of repeated exposure on depression scores via the elicitation of powerful positive emotions and neuronal activity. It is firstly hypothesised regular listening to Drops will improve depressive symptoms by inducing activity in the PFC, eliciting positive emotions and increasing emotional regulation. Secondly, it is predicted that Drop apprehension will improve performance on WM tasks, such as the Counting Span Task, via increased PFC activity, reduced depression and cognitive regulation. Lastly, it is hypothesised that positive effects of regular Drop apprehension on depression and WM will have longitudinal benefits for at least one week.

## 3 Method

### 3.1 Participants

All interested participants were first screened the week prior with the Depression Anxiety Stress Scale short version (DASS-21; Lovibond & Lovibond, 1995). To be eligible, a minimum score for mild depression (10 out of 42) was required. In total, 174 people completed the screening DASS-21 (male = 38 (22%), female = 135 (78%), age M (SD) = 20.17 (3.16), age range = 21). Of those, 25 (14%) scored within the mild category, 33 (19%) within the moderate category and 7 (4%) in the severe category, resulting in 65 (38%) eligible participants. Eligible participants were sent an email with information on how to arrange laboratory sessions (see Appendix A). Disqualified participants who scored lower than 10, were sent an email informing they could not continue (see Appendix B).

Only 19 (11% of screened participants) signed up for the main study. Seven of these participants (37% of those enlisted) had obtained a professional mental health diagnosis in the past year, including depression, anxiety, post-traumatic stress disorder (PTSD), and bipolar. As well as receiving treatment, such as medication (e.g. sertraline, quetiapine, lamotrigine, diazepam, and fluoxetine), counselling, and cognitive behavioural therapy (CBT).

Those with dreadlock, afro or cornrowed hair were also excluded, due to electroencephalogram (EEG) electrodes not being able to rest on the scalp. Participants who did not have normal or corrected to normal vision and hearing were excluded, to ensure all stimuli were perceived similarly.

Therefore, a total of 19 undergraduate students from the University of Kent participated via the research participation scheme (RPS) for course credits and a £50 prize draw. These were divided between Experimental condition (n = 10, male 2 (20%), female 8 (80%), age M (SD) = 22.11(4.17), range = 18-29) and Control condition (n = 9, male 2 (22%), female 7 (78%), age M (SD) = 19.78 (2.82), range = 18-27). However, two participants were excluded from EEG analysis due to uncontrollable interruptions or unusable data, leaving 17 for analysis (Experimental condition: n = 9, male 2 (22%) Female 7 (78%), age M (SD) = 22.11 (4.17), range = 18-29, mild depression n = 5 (56%), moderate depression n = 4 (44%), severe depression n = 0 (0%). Control condition: n = 8, male 1 (12%), female 8 (88%), age M (SD) = 19.75 (3.01), range = 18-28, mild depression n = 3 (38%), moderate depression n = 4 (50%), severe depression n = 1 (12%)).

Participants gave written informed consent prior study attendance. The study was approved by the School of Psychology local ethics committee at University of Kent.

### 3.2 Procedure

During the Pre- intervention laboratory session, participants were provided study and task information via an information sheet (see Appendix C). Written consent was then obtained with a consent form (see Appendix D). After, participants were directed to the computer screen and completed the laboratory session one Qualtrics questionnaire (see Appendix E). EEG and ECG were then fitted and ease of artefacts occurring demonstrated. Approximately one hour was required to set up all equipment.

Next, the Counting Span Task was verbally explained to participants with an example (see Figure 2). Understanding was then checked and the task started. After, the laboratory music task was explained, emphasising participants only had 2 seconds to respond. Earphones were fitted, volume checked and adjusted to a comfortable yet clear level for each participant. All participants (those in the Experimental and Control conditions) listened to the same music clips containing Drops during the laboratory music tasks. EEG and ECG were recorded throughout each task, taking approximately 60 minutes to complete. Once finished, EEG, ECG, and earphones were removed and a ‘log sheet’ provided (see Appendix F).

Over the 2-week intervention period, the lead researcher sent daily emails to participants before 10am, containing a Qualtrics link. Participants were asked to listen to half an hour of preselected music (see subsections online music task and online questionnaires), complete the Positive and Negative Affect Scale (PANAS) short version (Kercher, 1992;

Mackinnon et al., 1999), and answer questions regarding personal use and personal effect of music apprehended (see Appendix G). These created 12 separate 30-minute daily tasks which were distributed randomly. On days 7 and 14, participants instead completed the DASS-21 to record a more detailed assessment of depression. Participants were informed they could miss one day a week but must provide reasoning.

After, participants attended a second pre-arranged Post-intervention laboratory session. This was similar to Pre-laboratory session one, however a different Qualtrics questionnaire was completed (see Appendix H). Participant log sheets were collected and completion of daily tasks checked. Participants were then given a third laboratory session reminder slip (see Appendix I).

In the Follow-up laboratory session, participants only completed the laboratory session three Qualtrics questionnaire (see Appendix J), the Counting Span Task and the music laboratory task. Once finished, participants were provided a verbal and written debrief (see Appendix K). For a visual representation of the study procedure see Figure 1.

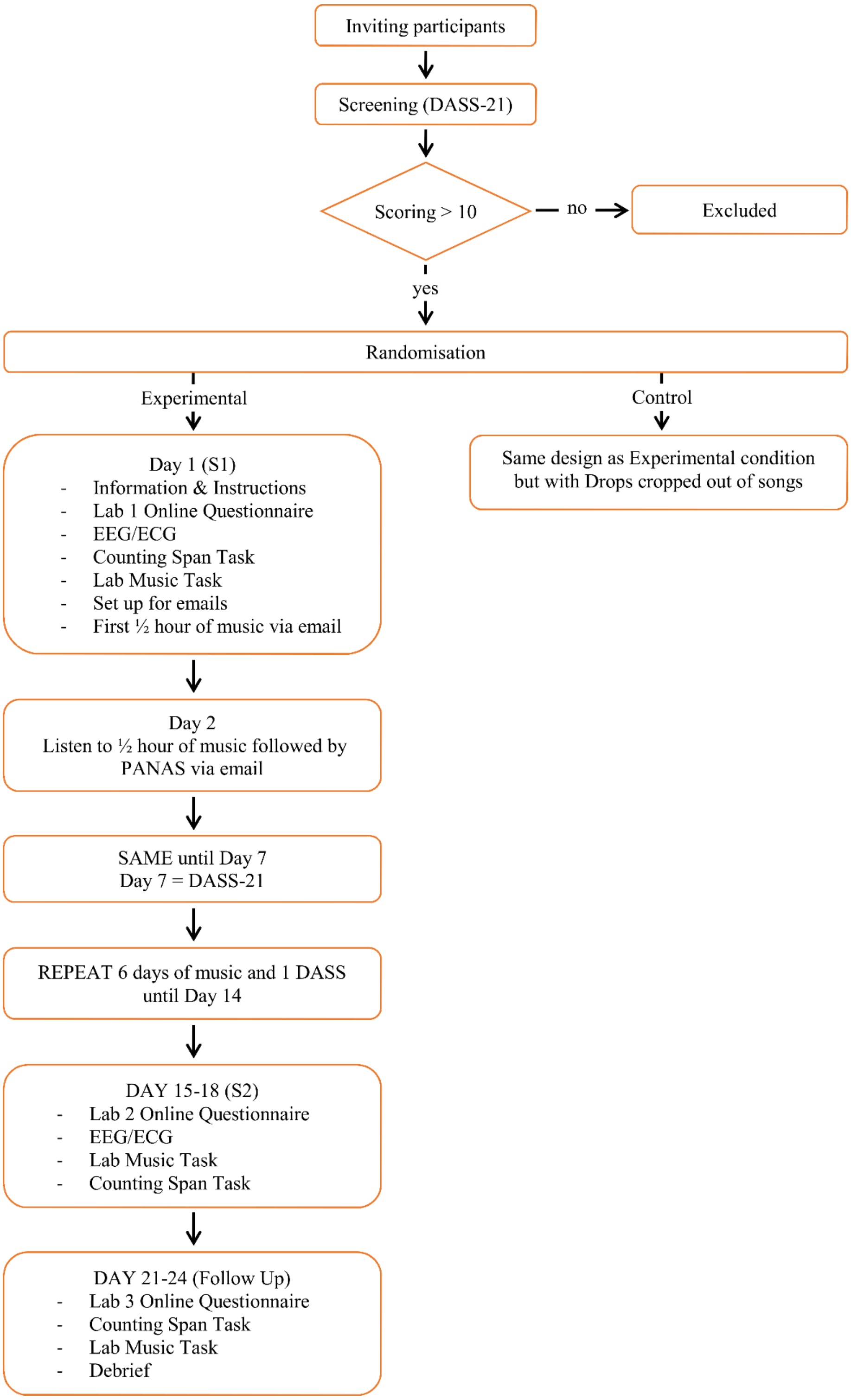



*Figure 1*. Flow diagram of study design, including the three laboratory sessions (Pre-, Post-intervention, and Follow up), daily music, depression anxiety and stress scale (DASS-21; Lovibond & Lovibond, 1995), positive and negative affect scale (PANAS; Kercher, 1992; Mackinnon et al., 1999), and Counting Span Task activities.

## 3.3 Materials

### 3.3.1 Online music task.

Originally, 338 songs containing Drops from the genres; Dance, Electronic dance music (EDM), Trance, House, Dubstep and Drum & Bass were collected. Songs were naturalistic, created by numerous artists, and contained lyrics. For instance, 'Wanna' by Catchment and 'Heart on Fire' by Wolf Krew Feat. Rebecca King were included songs. After screening and interrater researcher agreement, the 200 most appropriate songs were used to create 39 10-minute music pieces containing multiple genres with numerous Drop strengths and no adverse negative themes. Songs were implemented into 12 online Qualtrics questionnaires (see Appendix G for example), which where piloted (N = 7) to ensure practicality and appropriate use. The control stimuli consisted of the same songs over the two-week intervention, however with Drops cropped out. Other musical consumption was not controlled for. However, to account for any behavioural changes throughout the intervention, participants were instructed to keep a normal routine and utilise music as they ordinarily would. Participants also documented activities engaged in across the two-week intervention, enabling insight into adherence (See Figure 13 and Table 9).

### 3.3.2 Laboratory music task.

The songs and procedure for the laboratory music task were replicated from a previous paper (Turrell et al., in preparation). Pre-released songs from various artists were used to create clips, meaning laboratory clips also contained lyrics to varying degrees. A total of 90 randomised 20-second clips of Drops from a range of genres, including Dance, EDM, Trance, House, Dubstep and Drum & Bass were presented to all participants. Applied clips were selected from an original pool of 180 songs collected. Interrater researcher agreement identified Drops and where they occurred, noting the times. Recorded Drop times were then implemented into coding, cropping songs into 14 seconds prior time of Drops (pre-Drop), 6 seconds after time of Drops (post-Drop), and including 1 second of fade in and out. These 180 Drop clips were then piloted (N = 52) on numerous musical characteristics, including familiarity, Drop strength, and participant's excitement using a 5-point sale (1 = 'Not familiar at all' and 5 = 'Extremely familiar') and two 10-point scales (10 = 'Extremely Strong/Exciting' and 1 = 'Not strong/exciting at all'), respectively. This enabled the structured randomised selection of 90 clips containing a range of Drop strengths and low familiarity. In the laboratory music task, the question "How excited did you feel?" was presented after each Drop clip and required the selection of a representative keyboard number corresponding to the scale 1 ‘Not excited’ and 9 ‘Very Excited’ within two seconds.

#### 3.3.3 Working memory task.

WM was assessed using a Counting Span Task developed based on Conway et al. (2005). Screens with random numbers of targets (dark blue circles) and distracters (light blue circles and dark blue squares) were presented (see Figure 2). These screens were displayed for 5 seconds followed by the question “How many targets per screen?” and “screen 1/1” where participants entered answers via the keyboard. If gave the correct answer, participants then counted targets for two screens and remembered the sequential order of the two counted numbers. For each correct answer, the number of screens increased by one. However, if answered incorrectly the number of screens decreased by one. The task would continue until participants answered incorrectly three times, at which point the task would end.


*Figure 2*. Example of the Counting Span Task, containing instruction screens, screens with targets (dark blue circles) and distractors (light blue circles and dark blue squares) and response screens.

### 3.3.4 Online questionnaires.

Two questionnaires were implemented into the 2-week intervention via Qualtrics: the PANAS and DASS-21. PANAS was used during the intervention after participants listened to daily 30-minutes of music. DASS-21 was used as a screening method for participant selection and on days 7 and 14 of the intervention. Also, questions regarding enjoyment and familiarity of songs, and activities participants engaged in whilst music listening were included (see Appendix G for example).

A further three laboratory Qualtrics questionnaires were created, all also including the DASS-21. However, the questionnaire in Pre-laboratory session one also contained questions regarding participants' diagnosis and treatment for depression (see Appendix E). Whilst Post-laboratory session two had additional questions on musical ability, and familiarity and social contexts of apprehended songs (see Appendix H). Meanwhile, Follow-up laboratory session three only included the DASS-21. See Figure 1 for the breakdown of questionnaires and tasks.

### 3.4 EEG and ECG

During the testing phase for both Counting Span and laboratory music tasks, a continuous EEG was recorded using active electrodes (ActiCap, Brain Products), 12bit resolution, 500 Hz sampling rate. Twenty-eight active electrodes were placed via the 10-20 international EEG Electrode Placement system (including electrodes; Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, C3, Cz, C4, TP9, CP5, CP1, CP2, CP6, TP10, P7, P3, Pz, P4, P8, PO9, Oz, PO10, and ground and reference electrodes; Figure 3). Two electrodes were placed on the right of and underneath the right eye, respectively, to record vertical and horizontal eye movements (EOG). For the music task, markers were used in conjunction with the EEG data to specify times when Drops occurred. ECG was recorded with two electrodes, placed on the right shoulder close to the collarbone and under the left chest, respectively.

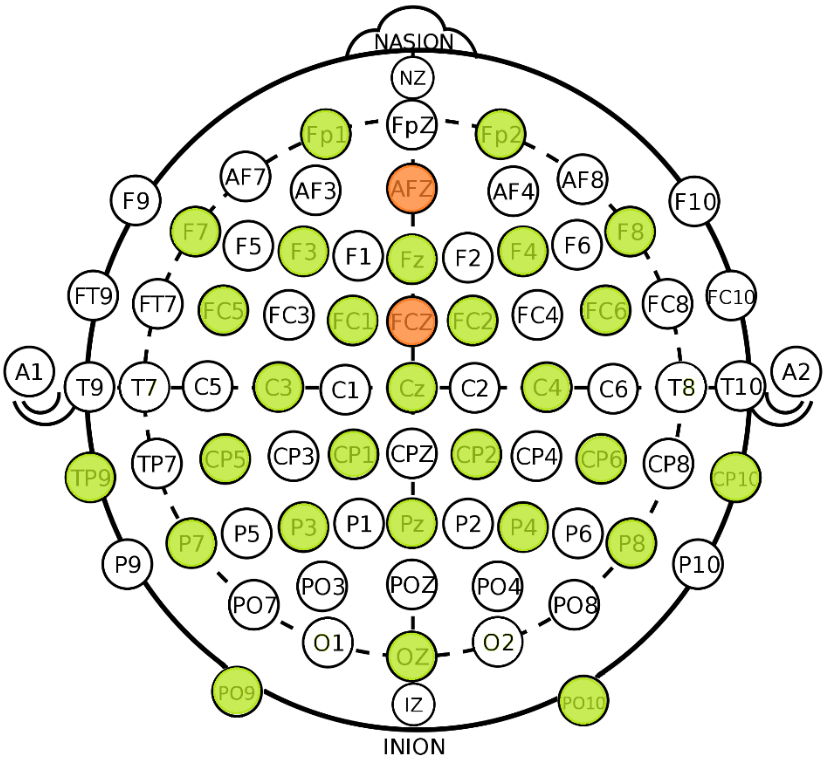



*Figure 3.* Electrode map of 10-20 international EEG Electrode Placement system to record EEG. Coloured electrodes indicate those used.

## 3.5 Statistical Analysis

### 3.5.1 Music EEG and ECG analysis.

EEG data were analysed using SPM 12 (statistical parametric mapping, Wellcome Trust, London, UK). First, datasets were converted to SPM format. Data was montaged to average electrode activity. Then a band-pass Butterworth filter order 5 with cut-off frequencies of 0.5-32Hz was applied. Frequency of 0.5Hz was chosen to remove general slow drift of the signal over the duration of the recording. Frequency of 32 was chosen for multiple reasons: Most importantly to remove noise with higher frequencies, and also due to no brain frequency responses to emotion being predicted. Additionally, as analysis is mostly focused on average activity over 1 second Pre- and Post-Drop, higher frequency activity would be cancelled out. Considering Nyquist frequency limit and aliasing effect of the frequency activities, having a maximum frequency of 32 Hz leads to the highest meaningful sampling rate of 128Hz ($4 \times 32$); meaning any sampling rate higher than 128Hz contains no further information. Therefore, data was downsampled to 128Hz to increase processing speed, reduce file sizes and avoid over-sampling the data. Eye-blinks were removed using topography-based correction based on activity of the FP2 electrode. Spatial confounds were indicated based on Singular Value

Decomposition (SVD) mode and sensor data was corrected using Signal-Space Projection (SSP) correction mode. A maximum of two components were removed from the EEG data.

Data was then epoched to one second before and one second after the onset of Drops, comprising Pre- and Post-Drop epochs, respectively. Subsequently epochs with peak-to-peak activity of more than 100µv were automatically detected and removed from the sample. Using a robust averaging method in SPM, epoch averages were calculated to achieve averaged Pre- and Post-Drop EEG activity. Finally, using the 3D source reconstruction method (normal template and EEG BEM head model) within SPM, one brain activity volume per condition per dataset was calculated.

Brain volumes were split based on session (Pre- or Post-intervention) and participant's condition (Experimental or Control). A 2 × 2 × 2 mixed-model three-way ANOVA was calculated with time (Pre- or Post-Drop) and session as within-subject factors and condition as the between subject factor. Also, t-test contrasts were run between Pre- and Post-Drop and Pre- and Post-intervention brain activity in Experimental vs Control conditions.

ECG data was recorded but not reported in this document.

### 3.5.2 Drop excitement ratings analysis.

For the self-reported ratings of excitement after each Drop in the laboratory music task, a 2 × 3 mixed-model ANOVA was conducted on mean excitement ratings. With session (Pre-, Post- and Follow-up) as a within participants factor, and condition (Experimental or Control) as the between subjects factor.

### 3.5.3 Working memory analysis.

Due to a limited number of trials in the Counting Span Task, EEG data collected was not analysed. However, behavioural alterations between Pre-, Post- and Follow-up scores on the Counting Span Task were assessed using a 2 × 3 mixed-model ANOVA with session (Pre-, Post- and Follow-up sessions) as the within subject factor and condition as the between subject factor.

### 3.5.4 Questionnaire analysis.

PANAS questionnaire data was analysed with 2 × 2 × 2 mixed-model ANOVA with time (first or last PANAS) and affect (positive or negative) as within factors and condition (Experimental or Control) as between subject factors. Whilst, DASS-21 data was first assessed with a priori descriptive analysis. After, DASS-21 responses were analysed with a 2 × 3 mixed-model ANOVA with Pre-, Post-, and Follow-up sessions as the within factor and Experimental and Control conditions as the between subjects factor. Furthermore, post-hoc paired-samples t-tests were conducted to explore the direction of mean differences.

### 3.6 Ethics

Ethics for both the pilot and intervention study were applied for and granted with the following details; Ethics ID: 2017150816830004574 and Expiry Date: 16-10-2019. Ethical concerns were considered and preventions implemented to reduce potential risk to participants. Anonymity and right to withdraw were administered via the participant code which was entered at the start of each task and provided to participants via the Debrief document.

## 4 Results

### 4.1 3D Source Reconstruction

#### 4.1.1 Superior temporal gyrus.

Analysis showed significant alterations in right superior temporal gyrus (rSTG; BA22r) neuronal activity. rSTG activity was significantly different across Pre- and Post-intervention sessions, as shown by the significant session main effect ($F$ = 9.20, $Z$ = 2.69, $p$ = .004 peak voxel activity uncorrected; Table 1). Specifically, average rSTG activity significantly increased during Pre-intervention sessions compared to Post-sessions ($t$ = 3.03, $Z$ = 2.91, $p$ = .002 peak voxel activity, uncorrected; Figure 4; Table 1).

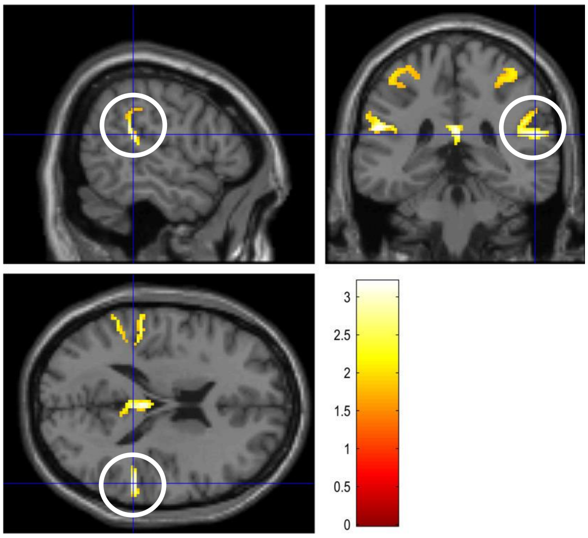
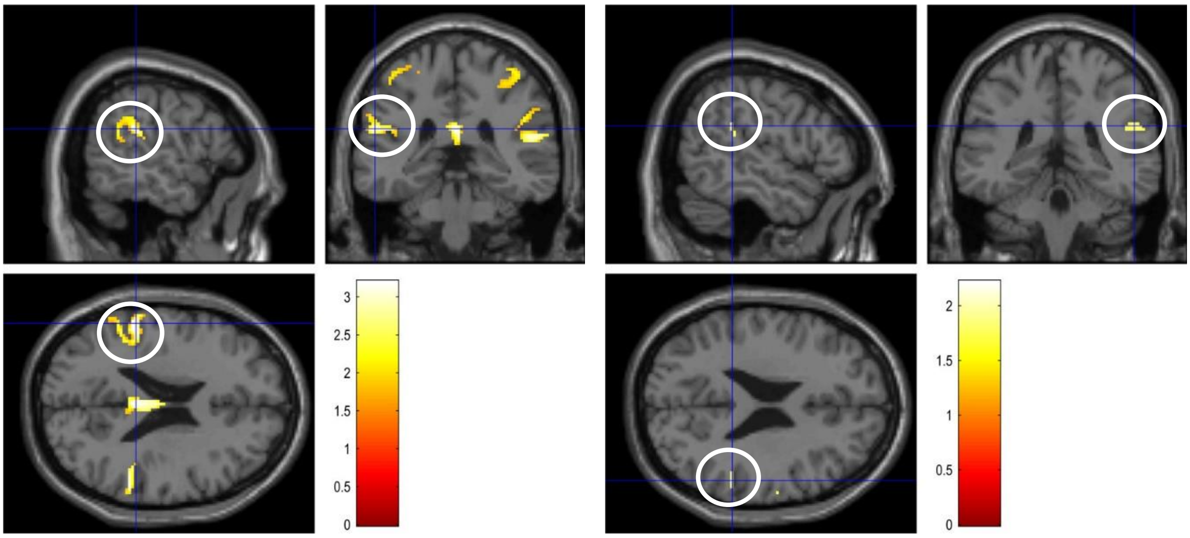



*Figure 4.* Right superior temporal gyrus (BA22r) activity across Pre- and Post-intervention sessions. BA22r activity was significantly greater in Pre- compared to Post-sessions. Statistical parametric activity maps are displayed with threshold $p < 0.05$ uncorrected, with minimum cluster size of 10 voxels (k = 10).

### 4.1.2 Supramarginal gyrus.

Activity in the supramarginal gyrus (SMG; BA40) significantly varied across session, condition and time. Within the main effect of session, left SMG (lSMG) activity was significant over Pre- and Post-intervention sessions ($F = 10.22$, $Z = 2.85$, $p = .002$ peak voxel activity uncorrected; Table 1). In particular, lSMG activity was significantly greater during Pre-intervention sessions over Post-sessions ($t = 3.20$, $Z = 3.06$, $p < .001$ peak voxel activity, uncorrected; Figure 5a; Table 1). Furthermore, right SMG (rSMG) activity was significant across conditions and sessions, with greater activity throughout Pre-intervention sessions in the Control condition ($t = 1.83$, $Z = 1.80$, $p = .036$ peak voxel activity, uncorrected; Figure 5b; Table 1).




(a) (b)

*Figure 5.* (a) lSMG (BA40l) activity across Pre- and Post-intervention sessions. Activity in the lSMG was significantly greater in Pre-sessions over Post-sessions. (b) rSMG (BA40r) activity across conditions and sessions. Activity in the rSMG significantly increased within Pre-intervention sessions of the Control condition. Statistical parametric activity maps are displayed with threshold $p < 0.05$ uncorrected, with minimum cluster size of 10 voxels (k = 10).

Additionally, activity in the lSMG significantly differed across conditions and Pre- or Post-Drops. Specifically, lSMG activity increased in the Experimental condition throughout the apprehension of Post-Drop music clips ($t = 1.81$, $Z = 1.79$, $p = .037$ peak voxel activity, uncorrected; Table 1).

### 4.1.3 Inferior frontal gyrus.

Inferior frontal gyrus (IFG; BA45 & BA47) activity also altered according to condition, session and time. In fact, left IFG (lIFG; BA47l) activity significantly increased during the Experimental condition and Post-Drop listening ($t = 1.97$, $Z = 1.94$, $p = .026$ peak voxel activity, uncorrected; Table 1).

Furthermore, right IFG (rIFG; BA45r) activity increases were marginally significant within the interaction of conditions, sessions and Pre- or Post-Drop ($F = 3.40$, $Z = 1.49$, $p = .068$ peak voxel activity uncorrected; Table 1). In particular, rIFG activity significantly increased in the Experimental condition, during Post-intervention sessions and when apprehending Post-drop music segments ($t = 1.84$, $Z = 1.82$, $p = .034$ peak voxel activity, uncorrected; Figure 6; Table 1).

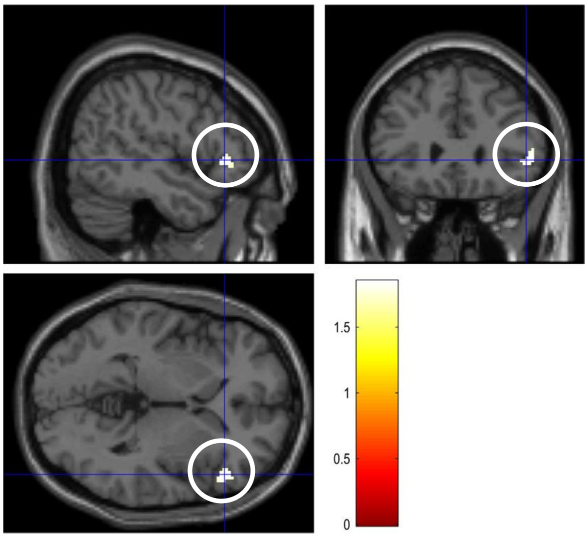
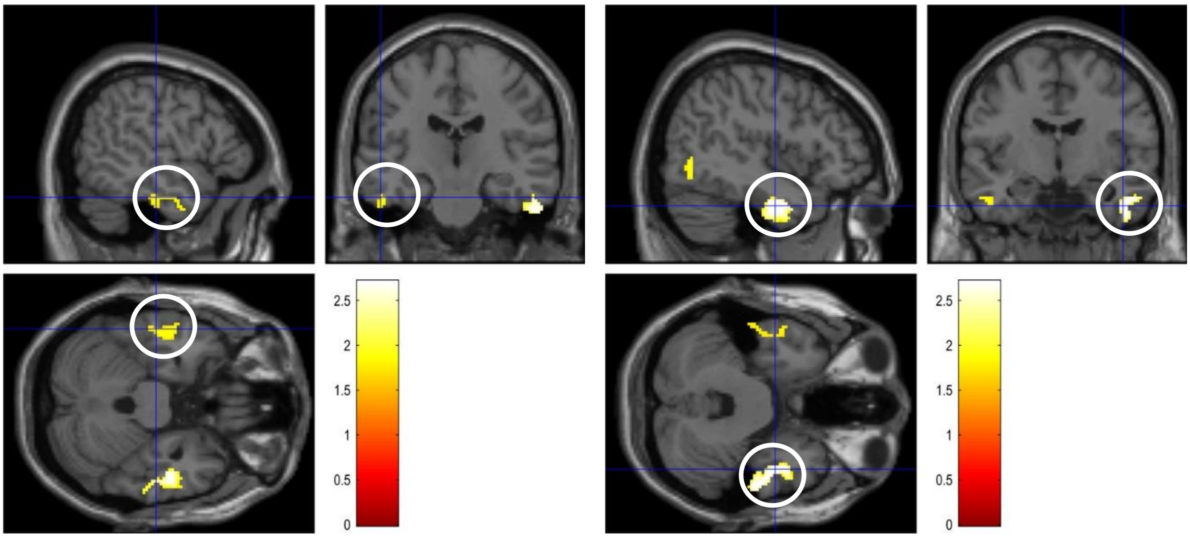



*Figure 6.* rIFG (BA45r) activity across conditions, sessions and Drop time. rIFG activity was largest in Post-intervention sessions of the Experimental condition when hearing Post-Drop music sections. Statistical parametric activity maps are displayed with threshold $p < 0.05$ uncorrected, with minimum cluster size of 10 voxels (k = 10).

### 4.1.4 Inferior temporal gyrus.

Activity in the inferior temporal gyrus (ITG; BA20) significantly altered across Pre- and Post-Drop listening ($F = 7.32$, $Z = 2.37$, $p = .009$ peak voxel activity uncorrected; Table 1). Also, bilateral ITG activity was greater Pre-Drop to Post-Drop (BA20l: $t = 1.85$, $Z = 1.82$, $p = .034$ peak voxel activity, uncorrected; Figure 7a; Table 1, BA20r: $t = 2.71$, $Z = 2.62$, $p = .004$ peak voxel activity, uncorrected; Figure 7b; Table 1).

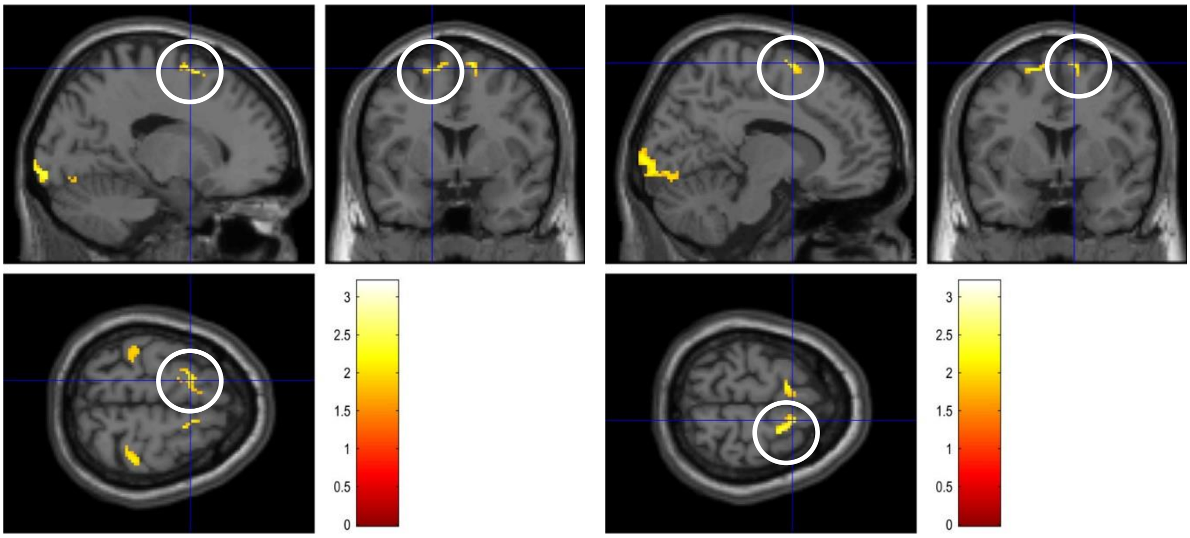



(a) (b)

*Figure 7*. (a) lITG (BA20l) activity when apprehending Drops. (b) rITG (BA20r) activity during Drop listening. Bilateral (BA20l and BA20r) activity was significantly greater within Pre-Drop apprehension over Post-Drop. Statistical parametric activity maps are displayed with threshold $p < 0.05$ uncorrected, with minimum cluster size of 10 voxels (k = 10).

### 4.1.5 Premotor cortex.

Additionally, premotor cortex (PC) including supplementary motor area (SMA; BA6) activity altered bilaterally across Pre- and Post-intervention sessions (BA6l: $F = 5.30$, $Z = 1.97$, $p = .024$ peak voxel activity uncorrected; Table 1. BA6r: $F = 5.91$, $Z = 2.10$, $p = .018$. peak voxel activity uncorrected; Table 1). Also, bilateral PC and SMA activity was significantly greater throughout Pre-intervention sessions than Post-sessions (BA6r: $t = 2.43$, $Z = 2.37$, $p = .009$ peak voxel activity, uncorrected; Figure 8a; Table 1, BA6l: $t = 2.30$, $Z = 2.25$, $p = .012$ peak voxel activity, uncorrected; Figure 8b; Table 1).




(a) (b)

*Figure 8.* (a) Average lPC and SMA (BA6l) activity. (b) rPC and SMA (BA6r) activity average. BA6l and BA6r activity increased during Pre-intervention sessions over Post-sessions. Statistical parametric activity maps are displayed with threshold $p < 0.05$ uncorrected, with minimum cluster size of 10 voxels (k = 10).

Furthermore, PC and SMA activity significantly altered across conditions and Drop time. Specifically, PC and SMA activity increased within the Experimental condition and during Post-Drop music listening (BA6l: $t = 1.94$, $Z = 1.90$, $p = .028$ peak voxel activity, uncorrected; Table 1, BA6r: $t = 1.81$, $Z = 1.78$, $p = .037$ peak voxel activity, uncorrected; Table 1).

#### 4.1.6 Angular gyrus.

Lastly, activity in the left angular gyrus (lAG; BA39l) was significantly greater during the Experimental condition over Control ($t = 1.74$, $Z = 1.72$, $p = .043$ peak voxel activity, uncorrected; Table 1). Also, lAG activity differed between Pre- and Post-intervention sessions, as average activity significantly increased during Pre-sessions than Post ($t = 2.33$, $Z = 2.28$, $p = .011$ peak voxel activity, uncorrected; Figure 9; Table 1).

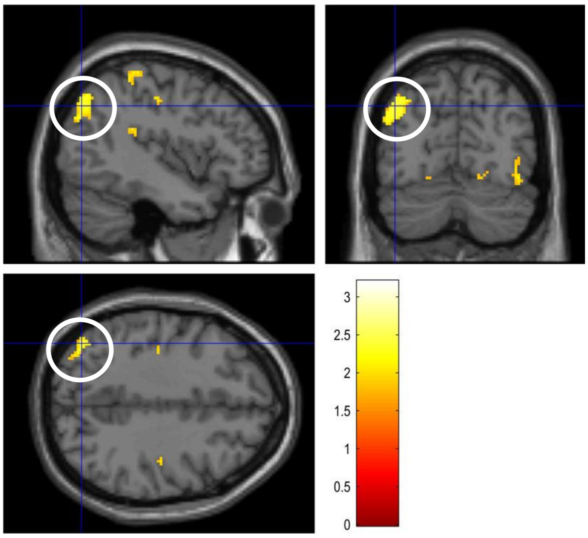



*Figure 9.* Average lAG (BA39l) activity was significantly different across sessions, with increased activity throughout Pre-intervention sessions over Post-sessions. Statistical parametric activity maps are displayed with threshold $p < 0.05$ uncorrected, with minimum cluster size of 10 voxels (k = 10).

Table 1. Results from 3D source reconstruction, including all main effects, interactions, and t-tests

| Contrast | Brain Area | BA | | | | MNI | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | KE | *F*/T | *Z* | puncorr | x | y | z | |
| Main Effect Session | rSTG | 22 | 120 | 9.20 | 2.69 | .004** | 56 | -36 | 18 | |
| | lSMG | 40 | 180 | 10.22 | 2.85 | .002** | -56 | -34 | 22 | |
| | rIOG | 19 | 174 | 6.64 | 2.25 | .012* | 48 | -76 | -4 | |
| | lIOG | 18 | 175 | 6.75 | 2.27 | .012* | -12 | -98 | -8 | |
| | rPC | 6 | 25 | 5.91 | 2.10 | .018* | 16 | 0 | 68 | |
| | lPC | 6 | 28 | 5.30 | 1.97 | .024* | -16 | 0 | 66 | |
| Main Effect Time | rITG | 20 | 408 | 7.32 | 2.37 | .009** | 46 | -8 | -32 | |
| | lPMC | 4 | 17 | 5.01 | 1.90 | .029* | -44 | -6 | 10 | |
| | rIOG | 19 | 15 | 4.73 | 1.84 | .033* | 40 | -66 | 0 | |
| Interaction Session × Time | lFPC | 10 | 11 | 4.72 | 1.84 | .033* | -28 | 48 | -6 | |
| Interaction Condition × Session × Time | rIFG | 45 | 77 | 3.40 | 1.49 | .068 | 50 | 28 | 0 | |
| | lPVC | 17 | 134 | 2.98 | 1.37 | .086 | -2 | -94 | 6 | |
| Condition – Experimental > Control | lAG | 39 | 50 | 1.74 | 1.72 | .043* | -48 | -70 | 32 | |
| Condition – Control > Experimental | rIOG | 18 | 60 | 1.99 | 1.95 | .025* | 38 | -90 | -4 | |
| Intervention Session – Pre > Post | lSMG | 40 | 370 | 3.20 | 3.06 | .001*** | -56 | -34 | 22 | Figure 5a |
| | rSTG | 22 | 184 | 3.03 | 2.91 | .002** | 56 | -36 | 18 | |
| | lPMC | 4 | 33 | 2.19 | 2.14 | .016* | -46 | -16 | 48 | |
| | rPG | 1 | 141 | 2.19 | 2.14 | .016* | 42 | -34 | 62 | |
| | rPC | 6 | 64 | 2.43 | 2.37 | .009** | 16 | 0 | 68 | Figure 8a |
| | lPC | 6 | 90 | 2.30 | 2.25 | .012* | -18 | 8 | 62 | Figure 8b |
| | rFPC | 10 | 150 | 1.82 | 1.79 | .036* | 38 | 52 | 0 | |
| | lFPC | 10 | 47 | 1.75 | 1.73 | .042* | -26 | 46 | 4 | |
| | lAG | 39 | 214 | 2.33 | 2.28 | .011* | -42 | -72 | 38 | Figure 9 |
| | rIOG | 19 | 407 | 2.58 | 2.50 | .006** | 48 | -76 | -4 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time – Post-Drop > Pre-Drop | rPMC | 4 | 37 | 2.19 | 2.15 | .016* | 44 | -4 | 12 | |
| | lPMC | 4 | 48 | 2.24 | 2.19 | .014* | -44 | -6 | 10 | |
| | rFPC | 10 | 145 | 2.01 | 1.98 | .024* | 38 | 52 | 0 | |
| | lFPC | 10 | 148 | 1.97 | 1.94 | .026* | -35 | 52 | 2 | |
| Time – Pre-Drop > Post-Drop | rITG | 20 | 495 | 2.71 | 2.62 | .004** | 46 | -8 | -32 | Figure 7b |
| | lITG | 20 | 138 | 1.85 | 1.82 | .034* | -52 | -20 | -26 | Figure 7a |
| | rIOG | 18 | 37 | 1.82 | 1.80 | .036* | 20 | -88 | -12 | |
| | lIOG | 18 | 43 | 1.77 | 1.75 | .040* | -20 | -86 | -10 | |
| | rIOG | 19 | 139 | 2.17 | 2.13 | .017* | 40 | -66 | 0 | |
| Condition × Session – Control Pre > Experimental Post | rPMC | 4 | 41 | 1.83 | 1.81 | .035* | 62 | -4 | 18 | |
| | rSMG | 40 | 27 | 1.83 | 1.80 | .036* | 54 | -38 | 24 | Figure 5b |
| Condition × Time – Experimental Post > Control Pre | rSMA | 8 | 99 | 1.99 | 1.96 | .025* | 38 | 26 | 44 | |
| | lSMA | 8 | 61 | 1.96 | 1.92 | .027* | -28 | 22 | 50 | |
| | rPC | 6 | 12 | 1.81 | 1.78 | .037* | 8 | -18 | 72 | |
| | lPC | 6 | 10 | 1.94 | 1.90 | .028* | -8 | -14 | 72 | |
| | lIFG | 47 | 208 | 1.97 | 1.94 | .026* | -48 | 38 | -8 | |
| | lSMG | 40 | 19 | 1.81 | 1.79 | .037* | -58 | -34 | 24 | |
| Condition × Session × Time – Control Pre Pre > Experimental Post Post | lPVC | 17 | 134 | 1.73 | 1.71 | .044* | -2 | -94 | 6 | |
| Condition × Session × Time – Experimental Post Post > Control Pre Pre | rIFG | 45 | 77 | 1.84 | 1.82 | .034* | 50 | 28 | 0 | Figure 6 |

*Note.* STG for Superior Temporal Gyrus, SMG for Supramarginal Gyrus, PC for Premotor Cortex, PMC for Primary Motor Cortex, AG for Angular Gyrus, FPC for Frontopolar Prefrontal Cortex, IFG for Inferior Frontal Gyrus, IOG for Inferior Occipital Gyrus, ITG for Inferior Temporal Gyrus, PG for Postcentral Gyrus, PVC for Primary Visual Cortex, SMA for Supplementary Motor Area; r refers to right lateralisation, l refers to left lateralisation; **p* < .05 uncorrected, ***p* < .01 uncorrected, ****p* < .001 uncorrected; BA: Brodmann Area; Pre and Post refer to Pre- and Post-Drop, and Pre- and Post-Intervention based on indicated comparison.

Overall, numerous brain regions differed in activity between conditions, intervention sessions, and Drops. Six regions of activity were considered most important due their location and time of activity, including the STG, SMG, IFG, ITG, PC, and AG. Most activity altered between Pre- and Post-intervention sessions with greater activity in Pre-sessions, or in a combination of Experimental condition, Post-intervention and Post-Drop.

## 4.2 Drop Excitement Ratings

A 2 × 3 mixed model ANOVA with between factor condition and within factor intervention session was conducted on participants self-reported excitement ratings from 1 to 9 after listening to each 20 second Drop clip. The main effect of intervention session was marginally significant, $F(2, 30) = 2.680$, $p = .085$, $\eta p2 = .152$, suggesting differences in excitement ratings across Pre-, Post- and Follow-up sessions. Means imply that excitement ratings increased over sessions (Table 2).

*Table 2.* Means and standard errors for excitement ratings across Pre-, Post- and Follow-up sessions

| **Excitement Rating Session** | **Mean(SEM)** |
|---|---|
| Pre-intervention | 4.85(.33) |
| Post-intervention | 5.24(.33) |
| Follow-up | 5.25(.34) |

Meanwhile, the main effect of condition was not significant, meaning clips were rated equally exciting with (Experimental) and without (Control) Drops. Also, the interaction between mean excitement ratings and condition was not significant, suggesting similar excitement ratings across conditions and sessions (see Table 10).

## 4.3 PANAS Analysis

PANAS data was collected over days 1-6 and 8-13 within the two-week intervention. Thus, a maximum of 12 PANAS scores were collected for each participant (for individual trends, 12-day trends, means, and median positive and negative PANAS scores, see Table 11 and Table 12, as well as Figures 14-19).

Differences between Control and Experimental conditions across the two week intervention were evaluated using a 2 × 2 × 2 mixed model ANOVA in the following format; condition (Experimental and Control) by intervention day (first and last PANAS) by emotion (positive and negative). As participants were permitted to miss intervention daily tasks once a week, participants each had 10 to 12 PANAS scores. However, two participants were excluded due to missing data, leaving 17 in total.

No main effects; the first or last PANAS, emotions (positive and negative) nor condition (Experimental and Control) were significant. Also, interaction effects between intervention day and condition, and emotion and condition were not significant (Table 13). Nonetheless, the interaction between intervention day and emotion was significant, $F(1,15) = 9.004$, $p = .009$, $\eta p2 = .375$, implying significant changes in positive and negative PANAS scores between first and last intervention days. Further assessment via means suggested positive scores increased between first and last intervention days, whilst negative scores decreased (see Table 3 below).

*Table 3.* Means and standard errors for the interaction between first and last intervention days and positive and negative emotion PANAS items

| **PANAS Score** | **Intervention Day** | |
|---|---|---|
| | **First M(SEM)** | **Last M(SEM)** |
| Positive Score | 10.80(1.67) | 13.14(1.30) |
| Negative Score | 11.67(1.12) | 8.66(1.25) |

In addition, the three-way interaction between intervention day, emotion, and condition was marginally significant, $F(1,15) = 3.536$, $p = .080$, $\eta p2 = .191$, suggesting positive and negative PANAS scores between Control and Experimental conditions and first and last intervention days were different but required larger N for significance. Exploration of means displayed positive scores increased, and negative scores decreased between first and last intervention days for both conditions. However, there were greater increases in positive and reductions in negative affect between first and last sessions in the Control condition than the Experimental (see Table 4 below). Thus, the intervention was perhaps more beneficial to emotion when Drops were not included.

*Table 4.* Means and standard errors for the interaction between Control and Experimental conditions, first and last PANAS scores and positive and negative affect

| **Condition** | **PANAS Score** | **Session** | |
|---|---|---|---|
| | | **First M(SEM)** | **Last M(SEM)** |
| Experimental | Positive Score | 12.60(2.15) | 13.00(1.67) |
| | Negative Score | 10.20(1.43) | 8.60(1.60) |
| Control | Positive Score | 9.00(2.57) | 13.29(2.00) |
| | Negative Score | 13.14(1.71) | 8.71(1.92) |

## 4.4 DASS-21 Analysis

The DASS-21 enabled the assessment of depression levels across the intervention. First, exploratory a-priori descriptive analysis was conducted allowing for visual explorations of DASS-21 changes. After, a 2 x 3 mixed model ANOVA was run to investigate statistical differences in DASS-21 scores over intervention sessions (Pre-, Post-, and Follow-up) and conditions (Experimental and Control). Lastly, paired-samples t-tests were administered to assess directions of DASS-21 score alterations over intervention sessions and conditions.

### 4.4.1 A-Priori Descriptive graphs.

Basic a-priori analysis on DASS-21 scores across sessions and condition indicated alterations in depression severity. In Post-intervention and Follow-up sessions, there was an alteration from most participants scoring in Moderate, Severe and Extremely Severe depression categories to scoring Normal, and with more participants screening for Normal within the Experimental condition (see Figure 20 and Figure 21). Also, mean DASS-21 scores differed across intervention sessions, but reduced further across Pre-, Post- and Follow-up within the Experimental condition (see Figure 10 below).

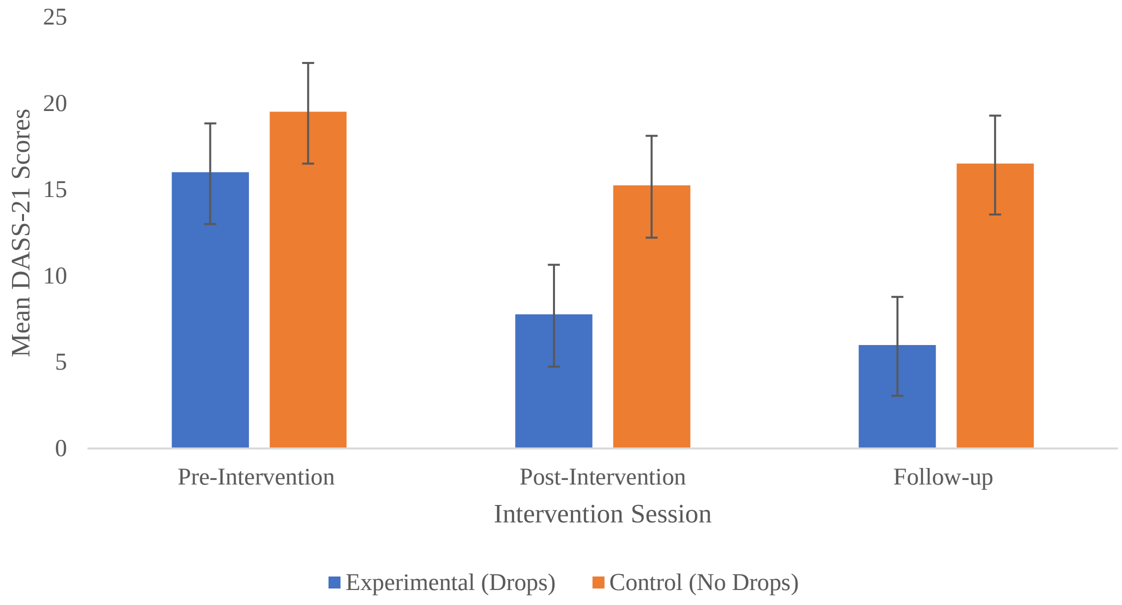



*Figure 10.* The mean DASS-21 scores across Pre-, Post- and Follow-up intervention sessions, as well as between Control and Experimental conditions.

### 4.4.2 2 × 3 DASS-21 ANOVA

A 2 × 3 mixed model ANOVA was conducted, referring to the between subjects factor, condition (Control and Experimental) by the within subjects factor, laboratory session (Pre-, Post-, and Follow-up). Mauchly's test of sphericity was conducted as DASS-21 scores had three levels. This was significant ($p$ =.001) and the Greenhouse-Geisser correction used. The main effect of laboratory session was significant, $F(1.216, 18.233) = 7.344$, $p = .011$, ηp2 = .329. This means DASS-21 scores were statistically different across Pre-, Post- and Follow-up sessions. To better understand these changes means were examined (see Table 5). These displayed reduced DASS-21 scores between Pre- and Post-sessions, suggesting the two-week music intervention was effective. Decreased DASS-21 scores then remained similar between Post- and Follow-up sessions, implying improved depression was maintained one-week after the intervention.

*Table 5.* Means and standard errors for Pre-, Post- and Follow-up laboratory sessions depression scores

| **Laboratory Session** | **Mean(SEM)** |
|---|---|
| Pre-intervention | 17.75(2.06) |
| Post-intervention | 11.51(2.09) |
| Follow-up | 11.25(2.03) |

*Note.* N=17.

Meanwhile, for condition (Experimental vs Control) the main effect was marginally significant, $F(1,15) = 4.255$, $p = .057$, ηp2 = .221, suggesting DASS-21 scores were different across Experimental and Control conditions, but were not fully significant. However, the large effect size suggests potential significance with higher N. Furthermore, the means over conditions show Control participants possessed higher average depression scores than Experimental condition participants (see Table 6).

*Table 6.* Means and standard errors for depression scores across Experimental and Control conditions

| **Condition** | **Mean(SEM)** |
|---|---|
| Experimental (Drops) | 9.93(2.38) |
| Control (No Drops) | 17.08(2.53) |

*Note.* N =17.

Despite session and condition having separate influences on DASS-21 scores, their interaction was not significant, $F(1.216, 18.233) = 1.672$, $p = .215$, ηp2 = .100, with Greenhouse-Geisser correction. This implies depression scores have similar patterns of change across Pre-, Post- and Follow-up sessions in both Experimental and Control conditions. However, again the medium effect size implies larger N could lead to significance. Also, means for the interaction (see Table 7) displayed prior levels of depression before the intervention across Control and Experimental conditions were different. Depression then decreased further in the Experimental condition than the Control (difference M = 8.22 and 4.25, respectively). DASS-21 scores then remained stable between Post- and Follow-up sessions in both conditions. Thus, Drops enable a greater reduction in depression scores than dance music without Drops, but declines seen in both are maintained one-week after the intervention. However, the interaction was not significant and should be considered with caution.

*Table 7.* Means and standard errors for depression scores between Experimental and Control conditions, and Pre-, Post- and Follow-up laboratory sessions

| **Condition** | **Pre-intervention Session** | **Post-intervention Session** | **Follow-up session** |
|---|---|---|---|
| | M(SEM) | M(SEM) | M(SEM) |
| Experimental (Drops) | 16.00(2.83) | 7.78(2.86) | 6.00(2.78) |
| Control (No Drops) | 19.50(3.00) | 15.25(3.04) | 16.50(2.95) |

*Note*. N=17.

Therefore, DASS-21 scores reduced throughout the intervention and across Pre-, Post- and Follow-up laboratory sessions. Differences between conditions and sessions became marginally and fully significant, respectively. This possibly suggests Drops in the Experimental condition better improve depression than the same music without Drops. Also, depression scores declined mainly between Pre- and Post-sessions, which then remained one week after the intervention. However, the interaction between condition and session was insignificant. Thus, whilst the intervention seemingly improved depression, the specifics are unclear and require post-hoc testing.

### 4.5 Working Memory Analysis

The Counting Span Task enabled a measurement of WM which varied across participants, sessions, and conditions (see Table 16). WM was assessed with mediation plots and a 2 × 3 (condition by session) mixed-model ANOVA.

#### 4.5.1 Median plots.

Median plots displayed an improvement between Pre- and Post-intervention and decline across Post- to Follow-up sessions within the Experimental condition (see Figure 11). However, in the Control condition medians showed stable levels of WM between Pre- and Post-intervention sessions and increased WM scores between Post- and Follow-up sessions, indicating improved WM during the week after the intervention.

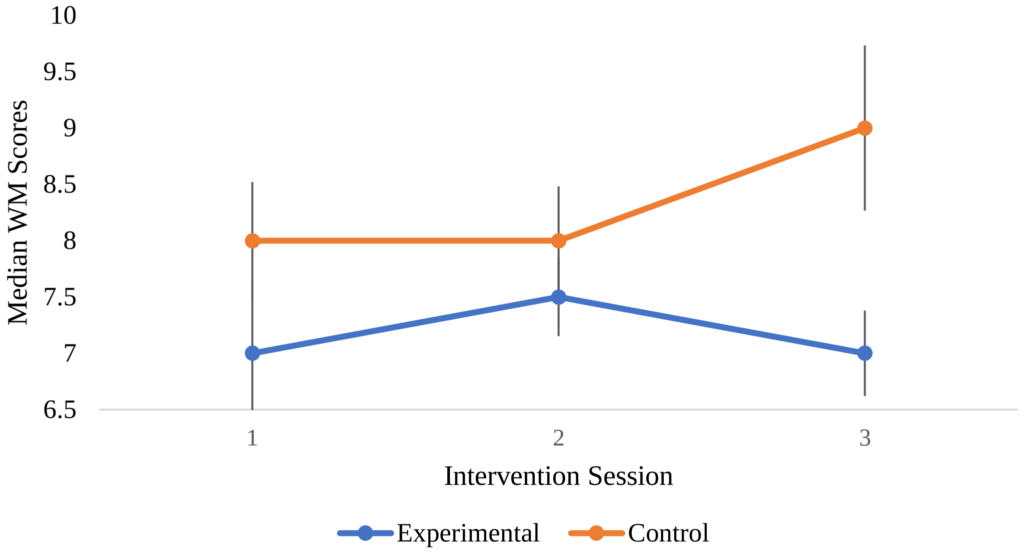



*Figure 11.* A graph of median changes in WM scores across Experimental and Control conditions and Pre- (1), Post- (2) and Follow-up (3) sessions.

Also, normalised median scores were examined and exhibited different WM ability patterns. Normalised WM scores suggested Experimental and Control conditions alter similarly across Pre-, Post- and Follow-up sessions (see Figure 12). WM scores increased between Pre- and Post-sessions to then reduce between Post- and Follow-up. However, this effect was slightly greater in the Experimental condition than the Control.

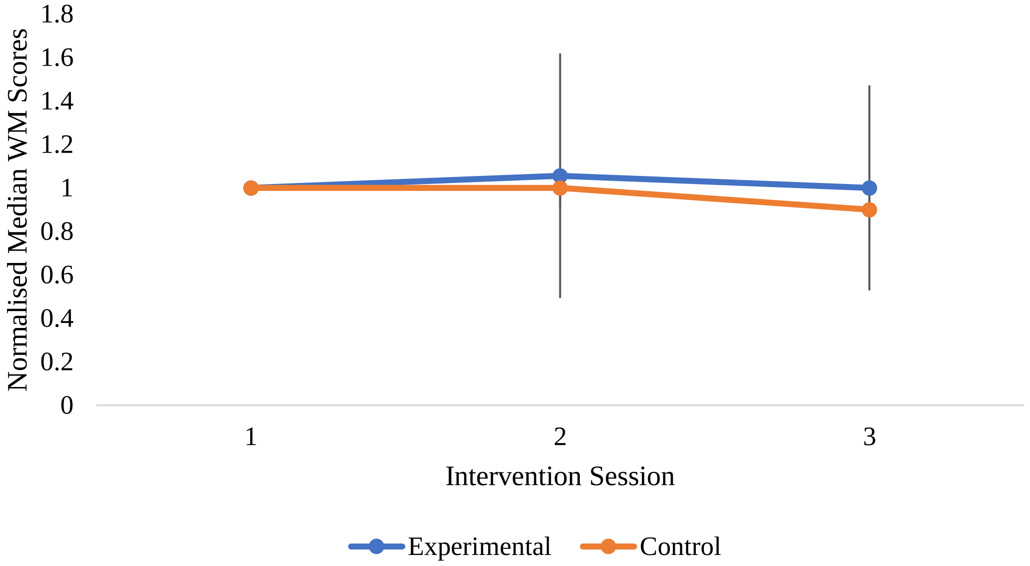



*Figure 12.* A graph of normalised median changes in WM scores across Experimental and Control conditions and Pre- (1), Post- (2) and Follow-up (3) sessions.

#### 4.5.2 WM ANOVA.

A 2 (condition) × 3 (session) mixed model ANOVA was conducted between Experimental and Control conditions across Pre-, Post- and Follow-up sessions. Results showed that all effects of condition and session on WM scores were non-significant, indicating little alteration within scores across Pre-, Post- and Follow-up sessions (Table 17), and between Control and Experimental conditions (Table 18). Furthermore, the interaction between condition and session was not significant (Table 19), suggesting WM scores did not differ within patterns of condition and session. However, means do suggest differences, with greater increased WM scores in the Experimental condition than the Control (see Table 8).

*Table 8.* Means and standard errors of WM scores between conditions and intervention sessions

| Condition | Pre-intervention Session | Post-intervention Session | Follow-up session |
|---|---|---|---|
| Experimental (Drops) | 6.60(.61) | 7.70(.43) | 7.40(.58) |
| Control (No Drops) | 8.00(.639) | 7.89(.45) | 7.78(.62) |

*Note.* Mean (Standard Error).

Thus, WM scores altered across Pre-, Post- and Follow-up sessions, generally improving between Pre- and Post-sessions to then decline. These changes are somewhat greater in the Experimental condition, suggesting Drops influence WM abilities. However, no effects were significant, raising ambiguity to the cause of WM changes which are potentially due to practice effects.

# 5 Discussion

## 5.1 Overview Results

This research offers the first exploration into repeated Drop processing effects on emotive brain networks and depression treatment. Numerous regions of brain activity significantly differed across Control and Experimental conditions, Pre- and Post-sessions and Pre- to Post-Drop. These include the superior temporal gyrus (STG; BA22), supramarginal gyrus (SMG; BA40), inferior frontal gyrus (IFG; BA45/47), inferior temporal gyrus (ITG; BA20), premotor cortex (PC; BA6), and angular gyrus (AG; BA39). This activity contradicts the first hypothesis, as brain regions are outside the prefrontal cortex (PFC). However, these brain areas are relevant to music processing, music-emotions, and depression symptoms. Thus, hypothesis one is partially supported as Drops increase activity in emotive brain regions, though not the areas predicted.

Furthermore, results are mixed regarding Drops effects on emotion and depression. Excitement ratings after apprehending Drops clips increased across the intervention, implying greater emotive responses to Drops after repeated apprehension. Also, PANAS scores were significantly different across intervention days and emotions, as positive scores increased throughout the intervention and negative scores decreased. Thus, supporting the hypothesis that Drops can positively induce emotions. Although, with the addition of condition, the effect of the intervention on emotion becomes marginally significant with greater emotion alterations during the Control condition. This counters hypothesis one and indicates regular apprehension of dance music without Drops may improve positive emotion more than music with Drops.

Nonetheless, DASS-21 scores significantly differed across the intervention, with further reductions in the Experimental condition than the Control. This demonstrates Drops potentially greater influence on depression and improving symptoms over similar music without Drops. Therefore, in support of hypothesis one, Drops significantly improved depression. However, the interaction between condition and intervention session was not significant, raising ambiguity as to how depression scores alter within the intervention.

Meanwhile, hypothesis two indicating regular Drop apprehension will also improve working memory (WM), has little support. Greater increases in positive PANAS affects and reductions in DASS-21 scores across the intervention in the Experimental condition demonstrates a positive influence on emotion and depression. However, this did not transfer into counting span task performances, which remained similar throughout the intervention. Similarly, Drop apprehension did not alter PFC activity, meaning the predicted association between WM improvements, the PFC, and depression was not found. This suggests WM performance did not increase over the intervention and across conditions according to PFC activity and reduced depression. Therefore, hypothesis two was not supported.

Lastly, hypothesis three stated regular Drop apprehension would reduce depression and increase WM ability for at least one-week post intervention. No significant effects for WM undermine the hypothesis. However, depression scores decreased in the Experimental condition across the intervention and the week after. Thus, in support of hypothesis three, regularly listening to Drops may improve depression and benefits remain for at least one-week after the intervention.

## 5.2 Effects of the Intervention

### 5.2.1 On brain activity.

Differences in brain activity between Pre- and Post-intervention sessions demonstrate the neurological influence of repeated Drop listening. One main alteration seen across the intervention was reduced brain activity in several regions. These include the STG, SMG, PC, and AG, all of which associate to musical processing and anticipatory processes (Altenmüller et al., 2014; Chen, Rae, & Watkins, 2012; McDonald, 2006; Schaal et al., 2015b). This suggests after two-weeks of repeated Drop exposure, participants became familiar with Drops unique structure, perhaps increasing anticipation for the deviation and reducing activity in brain regions related to musical change assessment (Bravo et al., 2017; Koelsch, 2006; Wehrum et al., 2011). Thus, activity in numerous brain areas decreased in response to repeated Drop apprehension, associating with the attainment of Drops distinct structure.

However, altered activity in afore-mentioned brain areas also relates to emotional control and reduced depression symptoms (Bogert et al., 2016; Henderson et al., 2014; Li, Xu, & Lu, 2018). Depression can be indicated by irregular increased activity in several brain regions (Cieri et al., 2017). Thus, decreased activity after the intervention could indicate decreased excitability in brain areas affiliated with maladaptive depression behaviours, including negative biases (Koch et al., 2018). This implies that repeated apprehension of dance music and Drops within the intervention reduces brain activity in regions related to maintaining negative symptoms of depression.

Therefore, repeatedly hearing dance music over two-weeks, whether it contains Drops or not, alters brain activity. These changes due to repeated dance music and Drop apprehension are associated with activity in previous effective music therapies (MT; Garza-Villarreal et al., 2015; Lee et al., 2016b; Raglio et al., 2016; Schlaug, Marchina, & Norton, 2008; Vines, Norton, & Schlaug, 2011). This suggests Drops could be a useful MT, evoking brain activity that potentially aids depression and other disorders, including stress, anxiety, brain injury, stroke and Dementia (Gardiner & Horwitz, 2015; Keough, King, & Lemmerman, 2017; Lee et al., 2016b; Pavlov et al., 2017; Raglio et al., 2017; Zhao et al., 2016).

Meanwhile, the intervention evoked different brain activity according to Experimental or Control conditions. There was greater activity in several brain regions during the Experimental condition, including the SMG, IFG, PC, and AG. This indicates that repeated Drop apprehension influenced brain activity differently over the same music without Drops, perhaps due to their unique structure enabling greater musical expectancy, arousal and emotion (Turrell et al., in preparation). Thus, repeated Drop apprehension over the two-week intervention elicited further brain activity, suggesting an exclusive influence on the brain and consequent behaviours.

Furthermore, only with repeated Drop listening within the Experimental intervention does brain activity increase within Post-interventions and Post-Drops. This suggests repeated Drop apprehension particularly influences how future Drops are perceived and patterns of brain activity. Recurrent Drop listening could enable their distinctive structure to be more anticipated, allowing more receptive brain regions to process Drops and their subsequent emotions. Thus, implying repeated listening of Drops distinct deviating structure relates to enhanced activity in several brain areas during Post-intervention and Post-Drop.

Additionally, increased brain activity within Post-intervention sessions during the Experimental condition, suggests extensive Drop listening could improve emotional regulation and depression. The IFG, a central region to music-emotions, emotional regulation, and depressive symptoms (Brattico et al., 2011; Chai et al., 2016), increased in activity within the Experimental condition and across the intervention. This indicates that repeated Drop apprehension may alter brain activity responses to Drops, associating with greater emotional responses, emotional-regulation and depression treatment. Thus, extensive Drop listening increases brain activity which in relates to improved positive music-emotions, emotional-control, and depression.

### 5.2.2 On mood.

Similar to alterations in brain activity, positive changes in participants mood occur according to intervention involvement. For instance, participant excitement ratings increased after repeatedly apprehending each Drop clip in Post- and Follow-up laboratory sessions. This implies that continually apprehending Drops perhaps augments positive emotions due to Drops distinct deviating structure. Thus, extensive Drop listening may induce greater positive music-emotions, such as excitement, compared to the same music without Drops.

Furthermore, positive influences on emotions due to repeated Drop listening was demonstrated through PANAS scores altered between the beginning and end of the intervention. Negative PANAS affect scores reduced whilst positive scores increased over the course of the intervention, indicating that repeated dance music and Drop apprehension induced positive and reduced negative emotions. Thus, two weeks of continuous dance music and Drop listening had a beneficial influence on emotion. However, this advantageous emotive effect of repeated apprehension is not individual to Drops, suggesting Drops influence may not be exclusive.

Meanwhile, DASS-21 scores declined over the two-week intervention, suggesting repeated dance music and Drop apprehension can effectively improve depression in young adults. Also, depression scores reduced further in the Experimental condition over the Control. This implies repeated Drop listening aids depression, with greater effects than the same music without Drops. Thus, Drops perhaps have a distinct and advantageous influence on Depression after two-weeks of repeated apprehension, making it important to explore Drops for future mental health treatments.

Additionally, DASS-21 scores remained decreased one week after the intervention. This indicates declined depressive symptoms from repeated dance music and Drop apprehension during the intervention persisted for one week. Thus, greater reductions in depression within the Experimental condition due to repeated Drop listening were maintained one week after Drop apprehension had stopped. This implies Drops can singularly and longitudinally improve depression, perhaps to a greater degree than different music and similar music without Drops.

Overall, the intervention effectively altered brain activity associated with musical experiences, music-emotions and reducing depression. Only the short-period of two weeks was required for notable changes in brain responses, which were greater with the inclusion and repeated apprehension of Drops. Also, positive emotions increased and negative decreased across the two-week intervention, allowing for potential improvements in depression, which were greater with repeated Drop listening. Therefore, Drops appear to have an advantageous influence on brain activity, emotions and improving depression compared to the same music without Drops. This demonstrates Drops possible ability to alter individual physiological and emotional responses to music and everyday life.

## 5.3 Interpreting Findings

### 5.3.1 Music processing.

Brain regions active when apprehending Drops relate to processing music features such as, tempo, melody, pitch and rhythm, and include the STG, SMG, IFG, ITG, PC, and AG (Altenmüller et al., 2014; Bianco et al., 2016; Bishop, Wright, & Karageorghis, 2014; Grahn

& Schuit, 2012; Kornysheva, von Anshelm-Schiffer, & Schubotz, 2011; Platel et al., 1997; Schaal et al., 2015b).

For instance, increased activity in the STG across Pre- and Post-intervention relates to the first acquisition of Drops structure and features during Pre-session, which may become predictable after repeated listening over the intervention. The STG is induced by apprehending complex music compared to other auditory stimuli, such as pink noise (Alluri et al., 2013; Angulo-Perkins et al., 2014; Kreutz, Russ, Bongard, & Lanfermann, 2003). Also, direct electrical stimulation to the right STG disturbs the ability to sing but not speak, suggesting the STG importance to musical abilities (Katlowitz, Oya, Howard, Greenlee, & Long, 2017). Thus, the STG may relate to the apprehension of Drops complex music structure and reduces in activity as Drops increase in familiarity throughout the intervention.

Furthermore, the IFG also processes musical features compared to other auditory stimuli, such as white noise (Flores-Gutiérrez et al., 2007). Increased IFG activity during the Experimental condition, Post-session, and Post-Drop may be in the assessment of musical features. When apprehending music compared to scrambled music, evoked IFG activity assesses music structure in reference to time (Levitin & Menon, 2005). Similarly, IFG's connectivity with the STG increases during the apprehension of music (Seger et al., 2013). Therefore, the IFG may be utilised in the processing of Drops features and alongside the STG forms a larger neuronal music network.

Meanwhile, Amusia, the inability to recognise and reproduce music, indicates a causal relationship between the IFG, STG and music perception. Voxel-based morphometry in Amusia patients demonstrated irregular grey matter volumes in the right IFG and STG (Albouy et al., 2014). Similarly, a lesion to the STG after an ischemic stroke resulted in Amusia (Hirel et al., 2014). Thus, damage to the IFG and STG implies their importance to music processing and when impaired music apprehension is reduced. This further indicates IFG and STG activity during Drop listening possibly relates to the processing of Drops unique structure and musical features.

Moreover, damage to the SMG and AG impedes the acquisition of music. An embolic stroke and chronic migraine damaging the right SMG and AG hindered the ability to read and play music (McDonald, 2006). Increased SMG and AG activity within Pre-intervention sessions may reflect their first processing of Drops structure and features. Also, greater activity during the Experimental condition and Post-Drop suggests the AG and SMG are especially utilised in the processing of Drop's deviations between Pre- and Post-Drop. This implies the SMG and AG could be central to processing music and have a causal role in the ability to understand and reproduce Drops.

Additionally, the ITG, STG, and PC are utilised in learning complex music (Satoh, Nagata, & Tomimoto, 2015; Ellis et al., 2012; Hudziak et al., 2014, respectively). Increased ITG activity across Pre- to Post-Drops could infer complicated music during Pre-Drops, requiring greater mental assessment, integration, and incorporation (Satoh et al., 2015). Whilst STG and PC activity are implied in complex melody and rhythmic training and discrimination (Ellis et al., 2012). Thus, greater ITG, STG and PC activity in Pre-Drop segments may reflect the processing of Drops complex, alternating structure.

Also, auditory and motor systems combined enable music learning, via associations between movements and sounds (Chen et al., 2012; Lega, Stephan, Zatorre, & Penhune, 2016). Altered PC activity in the Experimental condition, Pre-intervention and Post-Drop could relate to the integration of auditory and motor movements when first apprehending Drops (Lega et al., 2016). Functional magnetic resonance imaging (fMRI) has shown novices attempting to learn music melodies exhibit reduced bilateral STG and left PC activity (Chen et al., 2012). Higher abilities in acquiring melodies were associated with greater decreases in PC activity (Chen et al., 2012). Also, repetitive TMS over the PC reduced learning for auditory to motor relations, specifically impairing pitch-matching (Lega et al., 2016). Therefore, STG and PC activity are used in the processing of pitch, melodies and perhaps relate to understanding Drops in terms of sound and movement.

Likewise, the apprehension of music pitch is related to other brain regions. For example, determining absolute pitch has been associated with increased cortical thickness in left IFG, right SMG and bilateral STG (Dohn et al., 2015). Also, the STG facilitates pitch recognition and incongruity detection across language and music (Nan & Friederici, 2013). Meanwhile, the SMG enables pitch discrimination and memory maintenance, as damage via stroke and repetitive TMS causes disruption to pitch reproduction and recognition, respectively (Terao et al., 2006; Schaal et al., 2013; Schaal et al., 2015b). Similarly, PC and SMA activity relates to pitch accuracy and decreases over repeated pitch detection (Brown et al., 2013). Therefore, less SMG, STG and PC activity in Post-intervention sessions may reflect increased recognition and accuracy in pitch alterations within Drops after repeated listening.

However, another musical feature associated with similar brain activity is melodies. Alterations in STG activity over the intervention reflects changes in the assessment of melodies across repeated Drop exposure. The STG is more active during melody over rhythmic apprehension (Ellis et al., 2012). Also, a lesion to the left STG reduced the recognition and production of melodies, but not rhythms. This suggests different musical features, such as rhythms and melodies, are assessed independently and STG activity occurs during melody perception (Piccirilli, Sciarma, & Luzzi, 2000). Therefore, differing STG activity when apprehending Drops may relate to the assessment of complex melody alterations.

Furthermore, the PC processes music rhythm (Brown, Martinez, Hodges, Fox, & Parsons, 2004; Grahn & Schuit, 2012; Kornysheva, von Cramon, Jacobsen, & Schubotz, 2010). Increased PC activity in the Experimental condition and Post-Drop could infer the appraisal of unexpected, complex and highly deviating rhythmic Drop changes. Also, greater PC and SMA activity arises within beat sensitive individuals and when apprehending rhythmic rather than random sequences (Bengtsson et al., 2009; Grahn & Schuit, 2012). Thus, PC activity is possibly associated with processing rhythmic alterations happening between Pre- and Post-Drop.

Meanwhile, the STG assesses sound intensity in music and increased activity during Pre-intervention sessions could relate to elevated Drop intensity when first apprehended (Potes, Gunduz, Brunner, & Schalk, 2012). Intensity and novelty of Drops then decline after two weeks of listening, decreasing STG activity in the Post-intervention session. Thus, STG evaluates sound intensity, emphasising the requirement to standardise certain music features, such as volume. As this was done, STG activity may reflect reduced Drop intensity after repeated exposure.

On a different note, music familiarity relates to similar patterns of brain activity, including the IFG and AG (Altenmüller et al., 2014; Plailly, Tillmann, & Royet, 2007; Platel et al., 1997). Greater IFG and decreased AG activity in Post-intervention sessions possibly demonstrates increased familiarity with Drops over the intervention. Researchers imply IFG and AG are active during the apprehension of familiar music and odours (Plailly et al., 2007). Also, the AG is indicated in the attentive processing of unfamiliar, non-native music (Nan, Knösche, Zysset, & Friederici, 2008). Therefore, it is important to control for Drop familiarity, demonstrating why all Drops were piloted to ensure low familiarity (see Table 20 and *Figure 22*). Nonetheless, increased IFG and decreased AG activity suggests growing familiarity with Drops as more were apprehended throughout the intervention.

Additionally, similar brain activity is associated with processing music deviations and change. Music is a continuous stimulus enabling the progression of structure and tension that allows expectancy and predictions (Lehne et al., 2014). The STG, IFG, PC, SMG, and AG all relate to music expectancy and apprehending unanticipated music deviations (Bravo et al., 2017; Koelsch, 2006; Seger et al., 2013; Wehrum et al., 2011). Particularly, increased STG activity in Pre-intervention sessions when first apprehending Drops possibly results from processing Drops distinct structure and unexpected deviations in tones, melodies, key-changes, and structural anomalies (Koelsch, 2006; Lappe et al., 2013; Ono et al., 2015; Royal et al., 2016; Seger et al., 2013; Wehrum et al., 2011).

Meanwhile, IFG activity is greater during Post-intervention sessions and Post-Drops in the Experimental condition. The IFG is fundamental in predicting future music structures based on the previous assembly (Bianco et al., 2016). Thus, IFG activity may reflect participants improved ability to predict Drop structures after two-weeks of repeated listening to music deviations and melody alterations (Lappe et al., 2013; Royal et al., 2016; Seger et al., 2013; Wehrum et al., 2011). Therefore, increased IFG activity relates to increased expectancy in Drops as they are repeatedly apprehended across the intervention.

### 5.3.2 Music-emotions.

Active brain regions when repeatedly apprehending Drops also associate with experiencing music-emotions. Higher STG activity within Pre-intervention sessions could indicate greater pleasurable emotions when first apprehending Drops compared to after repeated listening. STG activity relates to simple, pleasurable emotions and damage results in musical Anhedonia (the incapability of experiencing pleasure from music; Hirel et al., 2014). Also, the STG is involved in aesthetic and happy rhythmic music appraisals (Baird, Walker, Biggs, & Robinson, 2014; Sachs, Ellis, Schlaug, & Loui, 2016). This indicates the STG's role in perceiving music-emotions and suggests greater emotive influences when initially perceiving Drops Pre-intervention. Thus, reduced STG activity implies repeated music tasks become tedious and boring. However, this is not supported by PANAS scores, suggesting positive affect increased over extensive Drop apprehension.

Nevertheless, STG activity also relates to experiencing negative emotions. In fact, increased STG activity arises during sad compared to neutral music (Oetken et al., 2017). Although, Oetken et al. (2017) suggest elevated STG activity allows positive self-image to be preserved during music-evoked sadness. Thus, greater STG activity within sad music increases and/or maintains positive feelings. It then becomes unclear whether declining STG activity across the intervention results from reduced pleasure or requirement to maintain positive emotions. However, greater positive and reduced negative PANAS scores in response to Drops post intervention suggests the latter. Therefore, repeated Drop apprehension possibly decreased negative affect in depressed patients, perhaps resulting in less requirement for the STG to maintain positive emotions.

Meanwhile, IFG activity can infer how music-emotions are experienced by listeners. Greater IFG activity indicates perceived music-emotions, the emotion communicated within the music, over felt music-emotions, those experienced by the listener (Tabei, 2015). Therefore, enhanced IFG activity across Drops and the intervention may relate to perceived rather than felt emotions, potentially reducing the validity of findings. However, alterations in participants PANAS scores over the intervention and in the Experimental condition suggest Drops positively influenced felt music-emotions. Nonetheless, differences between perceived and felt music-emotions during Drop apprehension should be assessed further.

Also, music-emotions relate to IFG activity when apprehending music with lyrics (Koelsch et al., 2006). Lyrics were included in Drop clips and daily music collections, thus IFG activity during Drop listening may associate with processing music and lyrical emotions (Brattico et al., 2011). IFG activity occurs during both happy and sad music- and lyric-emotions (Brattico et al., 2011). Thus, keeping lyrics in music stimuli alters brain activity and emotions experienced, making the emotive effects of Drops unclear. However, lyrics occurred during Pre- and Post-Drop, suggesting brain activity alterations across Drop apprehension may not only associate with lyrical processing, but also to appraising musical structure. Furthermore, IFG activity is affiliated with language and music processing, specifically to assessing semantics and syntax both lyrically and musically (Kunert, Willems, Casasanto, Patel, & Hagoort, 2015; Schön et al., 2010). Thus, increased IFG activity alongside greater positive affect in PANAS scores suggests positive music-emotions can be elicited via Drops unique structure and lyrics.

Furthermore, induced IFG and PC/SMA activity correlate with complex positive emotions, such as nostalgia and empathy (Barrett & Janata, 2016; Wallmark, Deblieck, & Iacoboni, 2018). This implies higher IFG and PC activity within Post-Drop segments in the Experimental condition possibly relates to increases in complex, pleasurable music-emotions over the course of the intervention. Increased positive PANAS scores, and greater Drop excitement evaluations, support IFG and PC’s relationship with strong pleasant emotions.

Thus, Drops potentially elicit complex pleasurable emotions, relating to different IFG and PC activity.

Additionally, IFG activity is associated with musical expectancy. Increased IFG activity relates to music deviations which evoke music-emotions (Lehne et al., 2014). This implies Drops tension and expectancy enabling structure could induce IFG activity which elicits music-emotions. Thus, increased IFG activity when apprehending Post-Drop segments suggests Drops distinct structure of build and dramatic change associates with musical expectancy and deviation. Also, greater IFG activity within the Experimental condition indicates further musical expectancy and tension when Drops are repeatedly processed. This implies frequent Drop apprehension relates to greater musical expectancy, deviation, and emotions. Increasing positive PANAS scores and excitement ratings over the intervention and in the Experimental condition reinforces this.

Moreover, IFG alongside STG activity appears during likable music apprehension (Joucla et al., 2018). Increased IFG and STG activity when music listening implies their combined role in processing music features and apprehending likable music (Joucla et al., 2018). Thus, greater STG activity within Pre-intervention sessions could infer elevated Drop liking when first heard. This suggests repeated Drop apprehension in the Experimental condition reduces excitement and music-emotions, as supported by larger increases in positive and reductions in negative PANAS scores during the Control condition. However, increased IFG activity within Post-sessions and Post-Drops in the Experimental condition possibly demonstrates increased Drop liking after repeated listening, as supported by higher excitement ratings Post-intervention. Although, developing Drop familiarity also increases IFG activity, making repeated Drops emotive influence ambiguous.

Also, greater liking of music, specifically preferences for rhythms and tempos, is associated with increased PC activity (Kornysheva et al., 2010; Kornysheva et al., 2011, respectively). In fact, inhibitory TMS to the left PC impedes ratings of tempo preferences but not other music features, such as timbre (Kornysheva et al., 2011). Thus, greater PC activity and excitement ratings in the Experimental condition, Post-intervention, and Post-Drop perhaps relates to increased music liking, as Drop's tempo and rhythm rapidly alter.

Additionally, music can improve emotional-regulation and is utilised every day to control emotions even when unattended (Bogert et al., 2016). This emotional-regulation in music associates with ITG, SMG, and PC activity (Bishop, Karageorghis, & Loizou, 2007;

Coombes, Corcos, Pavuluri, & Vaillancourt, 2012). Therefore, greater ITG, SMG and PC activity within Pre-intervention sessions and Pre-Drops suggests better emotional-regulation at the beginning of the intervention. However, this is contradictory to PANAS, Drop excitement, and DASS-21 results, showing improved positive and reduce negative effects.

Although, higher ITG and SMG activity within Pre-Drops and Post-Drops in the Experimental condition respectively, possibly indicates greater emotional control at Drops unique building (Pre-Drop) and deviating (Post-Drop) structure, which continuously develops alongside repeated Drop apprehension. However, emotional control was not assessed meaning conclusions on regulation improvement throughout the intervention are limited. Future research should expand and explore the effects of Drops on emotional-regulation.

Meanwhile, the ITG and AG do not often relate to music-emotions in previous literature, suggesting their activity is important for music processing, but not music-emotions. Although separate to music, ITG and AG activity is associated with emotion elicitation, indicating their emotive role (Kim et al., 2015; Machado, & Cantilino, 2017). Also, impaired emotional experiences relate to abnormal AG and ITG activity (Jang, Kim, & Jeong, 2017; Peters et al., 2016; Wu et al., 2017). Thus, the ITG and AG associate with emotions and emotional control, despite their reduced relationship with music-evoked emotions. This implies Drops, unlike other music forms, elicit ITG and AG activity, making them potentially more influential to improve emotion and emotional regulation in disorders, including depression.

### 5.3.3 Music and depression.

All six active brain regions throughout conditions, sessions, and Drops; the SMG, STG, IFG, ITG, PC, and AG, relate to depression symptoms and treatments (Henderson et al., 2014; Li et al., 2018).

The STG applies to depression in numerous ways, including irregular increased grey and white matter volumes within the STG and its AG connections (Besteher et al., 2017; Harada et al., 2018; Yang et al., 2017). This implies abnormal functioning between the STG and other emotive brain regions in depression. Thus, enhanced STG activity during Pre-intervention sessions could reflect greater irregular activity at the beginning of the intervention. This possibly demonstrates improved depression across the intervention as maladaptive STG activity in reduced in Post-intervention sessions. Lower DASS-21 scores Post-intervention, particularly in the Experimental condition, could also suggest Drops regulate STG activity and reduce depression symptoms.

Similarly, depression is associated with structural and functional differences in the SMG. Cortical SMG thickness and irregular connectivity are significantly greater in depressed individuals (Perlman et al., 2017; Zhu, Lin, Lin, Zhuo, & Yu, 2018a). Increased SMG activity during Post-Drops in the Experimental condition implies increased activity due to Drop apprehension. Also, greater SMG activity Pre-intervention suggests elevated activity alongside higher depression scores at the beginning. Thus, declined DASS-21 scores and SMG activity over the intervention perhaps show Drops regulated SMG activity, which evoked music-emotions and reduced depressive symptoms (Zhu et al., 2018a).

Furthermore, abnormal functional connectivity within the IFG, PC/SMA, ITG and AG in depressed patients suggests problems with emotional regulation (Chai et al., 2016; Lai, Wu, & Hou, 2017; Scheuer et al., 2017; Zhu, Lin, Lin, & Zhuo, 2017; Zhu et al., 2018b). Differing patterns of activity during the Experimental condition and/or over Pre- and Post-Drop for each brain region altered by repeated Drop listening, associated with improvements in depression scores. Thus, Drops possibly evoke activity in specific brain networks related to emotions, emotional control, and depression, leading to potential improvements.

In addition, Anhedonia; the reduction of pleasure and motivation in things rewarding, within major depressive disorder relates to increased STG activity (Yang et al., 2016). Therefore, greater STG activity during Pre-intervention sessions may be associated with more prominent depressive symptoms, such as Anhedonia. Thus, the reduction of STG activity between Pre- and Post-sessions is potentially beneficial and associated with increased motivation and reward during intervention participation. This is supported by elevated positive and decreased negative PANAS scores and improvements in depression scores.

Meanwhile, brain activity also provides information on the type and extent of depression recovery (DelDonno et al., 2017). For instance, depression remitters exhibit increased ITG cortical thickness, whilst non-remitters show reduced ITG thickness (Phillips, Batten, Tremblay, Aldosary, & Blier, 2015). Also, depressive ruminators with constant, unhelpful, and obsessive negative thoughts, displayed reduced problem-solving abilities related to declines in AG activity (Jones, Fournier, & Stone, 2017). Therefore, the induction of ITG and AG activity during Pre-Drop and Pre-intervention in the Experimental condition may associate with reduced depression rumination. This enables adaptive thought, improving long-term symptoms of depression and making remittance more likely. Significant depression reductions between Post- and Follow-up sessions and in the Experimental condition perhaps show Drops induce brain activity which decreases rumination and prolongs depression recovery for at least one week. However, non-significant interactions between sessions and conditions in depression scores imply Drops may not improve depression over dance music without Drops.

Furthermore, a main symptom and indication of depression is negative emotional bias (Henderson et al., 2014; Koch et al., 2018). This negative bias and reduced cognitive control relate to decreased activity within the STG, PC and ITG (Henderson et al., 2014; Renner et al., 2017; Segarra et al., 2016). Thus, abnormal STG, PC, and ITG brain activity indicate irregular emotional processing in depression. The induction of STG, PC and ITG activity during Pre-intervention sessions and Pre-Drop possibly implies Drops evoke activity allowing for greater emotional regulation and reduced negative biases. This is also seen via reduced negative affect PANAS scores and DASS-21 scores across the intervention. However, highest STG, PC and ITG activity occurred within Pre-intervention sessions, suggesting reduced activity Post-intervention and limited positive effects of Drops on problematic emotional biases in depression.

Moreover, depression is associated with reduced emotional regulation, alongside irregular IFG, SMG and AG activity and grey matter volumes (Herwig et al., 2018; Belden, Pagliaccio, Murphy, Luby, & Barch, 2015; Li, Wei, Sun, Zhang, & Qiu, 2017; Zhu et al., 2018c; Scheuer et al., 2017; Wu et al., 2017, respectively). Therefore, greater activity within these areas during the Experimental condition and repeated Drop apprehension could show Drops induce brain activity aiding impaired emotional regulation. Also, larger SMG and IFG activity during Post-Drop segments in the Experimental condition may demonstrate Pre- and Post-Drop deviations increase emotional regulation. This is further suggested by greater depression reductions in the Experimental condition, implying repeated Drop apprehension activates brain regions improving emotional control. However, greater AG activity within Pre-intervention sessions in the Experimental condition, suggests not all brain regions associated with Drops improve emotional regulation.

Additionally, regular Drop apprehension elicits similar brain activity to other effective depression treatments. Responsive patients to antidepressant and medication treatments exhibited increased IFG and AG activity (Hou et al., 2018; Shen et al., 2015). Therefore, IFG and AG activation indicates depression improvements and predicts reductions in depression scores (Shen et al., 2015). Increased IFG and AG activity during the Experimental condition, Post- and Pre-intervention respectively, perhaps implies Drops (as compared to the same music without Drops) evoke activity in regions important to depression recovery. This is also supported by significant declines in depression scores between Post- and Follow-up intervention sessions. However, AG activity is highest within Pre-intervention sessions, suggesting depression treatment with Drops may be limited.

Also, increased AG activation associates with longitudinal improvements in depression treatment (Strikwerda-Brown et al., 2015). This suggests greater AG activity during the intervention facilitates positive results within depression treatment. Greater reductions in depression scores across Pre-, Post- and Follow-up intervention sessions within the Experimental condition potentially relates Drop evoked AG activity with improved depression. Although, AG activity only increased throughout Pre-intervention sessions, reducing its association with depression improvements through repeated Drop apprehension.

Furthermore, remitters within a 12-week medication treatment for depression exhibited different IFG, SMG and ITG activity than those who did not recover (Karim et al., 2017). Therefore, different brain responses to treatment can perhaps signify the effectiveness of interventions. Here, IFG, SMG and ITG activity in the Experimental condition positively suggest repeated Drop apprehension is a potentially effective treatment for depression. This is further evidenced by reduced depression scores across intervention sessions and the Experimental condition. However, increased SMG activity in the Control condition accompanied by reductions in depression, also suggests dance music without Drops can be effective depression treatment.

### 5.3.4 Working memory.

No counting span WM task effects were significant across intervention sessions or conditions, despite brain activity alterations in IFG, STG, AG and PC suggesting improvements in WM depression deficits (Koelsch et al., 2006; Nan et al., 2008; Grahn & Schuit, 2012; Yüksel et al., 2018, respectively). Thus, brain activity related to regular Drop listening is associated with WM but does not translate to improved WM counting span task performance. One reason for this could be increased WM induced by Drops associates with music and music-emotions, but not to other WM tasks from different theories and definitions, such as the counting span task (Altenmüller et al., 2014; Cowan, 2017). Therefore, WM is perhaps being evoked during Drop apprehension through the activation of IFG, STG AG, and PC areas, but only relates to music WM and does not improve other WM types requiring different cognitive skills. Future research should explore Drops effects on different classifications of WM in more detail.

### 5.4 Study Limitations

When assessing results it is important to consider potential limitations, their influence, and how future research may improve. One disadvantage is the low sample size, only 19 participants make maintaining significant results difficult, as seen via frequent large effect sizes but only a few significant effects. Participant recruitment was problematic due to lack of incentive and high experiment demands. Future research will benefit from developing other recruitment methods that do not rely on students and a research participation scheme (RPS). Also, conclusions drawn from this research must be considered with some caution, as transferability of results are limited due to low N.

Similarly, most of the university student sample were not clinically diagnosed, making comparisons between findings and previous literature challenging as previous research predominantly utilises clinically depressed samples. This raises uncertainty of how transferable Drops as an intervention are in treating severe depression. Future research should implement similar Drop MT's in clinically diagnosed patients to assess effects.

Furthermore, the assessment of emotions in research is often explicit with stated instructions. This impacts how music is processed and related brain activity, as participants attend to Drops, rather than passively apprehending them. Such explicit attention to music induces similar brain activity in regions, such as the IFG (Osnes, Hugdahl, Hjelmervik, & Specht, 2012). This suggests changes in brain activity when apprehending Drops may relate to explicit music processing. Thus, future research should clarify what brain activity is a result of apprehending Drops and evoked music-emotions, and which relate to the explicit processing of music.

Additionally, music experience influences music processing, related brain activity, music-emotions, and effects on depression. Whilst, music experience was measured it was not assessed in relation to emotive and depression influences. Around 68% of participants possessed musical experience between 1 to 9 or more years for various instruments (see Figure 23 and Figure 24). Music experience alters the manner and accuracy of music feature perception through plasticity (Gagnepain et al., 2017; Matsui, Tanaka, Kazai, Tsuzaki, & Katayose, 2013). Differences are seen in the STG, IFG, SMG, and PC between musicians and non-musicians and the extent of musical experience (Angulo-Perkins et al., 2014; Bailey, Zatorre, & Penhune, 2014; Ellis, Bruijn, Norton, Winner, & Schlaug, 2013; Fauvel et al., 2014; Gagnepain et al., 2017; Hoenig et al., 2011; Matsui et al., 2013; Sato, Kirino, & Tanaka, 2015;

Schaal et al., 2015a; Seung, Kyong, Woo, Lee, & Lee, 2005). These differences in brain activity between musicians and non-musicians perhaps altered the influence of Drops on emotion and depression. Thus, future research should assess differences between Drops, brain activity, music-emotions and depression in varying degrees of musical training.

Moreover, other music consumption beyond the 30-minute daily intervention tasks was not controlled for. Instead, participants were asked to keep their normal routine throughout and use music as usual, meaning only the apprehension of the daily music tasks differed. Thus, whilst it is less clear whether intervention effects solely associate with dance music apprehension, it enables greater ecological validity. However, readers should be wary of reduced standardisation and future researchers could utilise alternatives, such as reflective diaries, to operationalise other music use.

The last limitation is EEG cannot be utilised to infer causation. Despite, greater reductions in depression scores in the Experimental condition when Drops were apprehended, it can only be established that brain activity relates to Drop listening and decreased depression scores. Although, future research can explore causation in depression via stimulation techniques, such as TMS and transcranial direct current stimulation (tDCS; Pavlova et al., 2018; Şalçini et al., 2018). Also, the investigation of brain damage in relevant brain regions and consequences to Drop apprehension, emotional regulation and depression scores can be assessed to further examine causation.

## 5.5 Practical Applications

Despite weaknesses, this research offers the first step in exploring Drops as a novel mental health intervention. MT is already established as an effective way to treat numerous mental health disorders, such as bipolar, schizophrenia, depression and anxiety (Chung & Woods-Giscombe, 2016; Jung, & Newton, 2009; Trimmer et al., 2016; Tseng et al., 2016). It can also be utilised to increase healthy exercise, reduce symptoms of pain, and improve attention (Clark, Baker, & Taylor, 2016; Sin, & Chow, 2015; Lesiuk, 2015). Drops evoke similar patterns of brain activity, including the STG, SMG, IFG, ITG, AG, and PC to other forms of effective MT (Garza-Villarreal et al., 2015; Lee et al., 2016b; Raglio et al., 2016; Schlaug et al., 2008; Vines et al., 2011). Therefore, Drops perhaps have the potential to elicit emotions, improve emotional regulation, and be applied to multiple treatments, similarly to existing interventions.

Furthermore, Drops are a plausible efficient, cost-effective and accessible treatment that can be easily implemented into daily lives. Currently, around 60% of those with a mental health disorder do not receive adequate treatment, emphasising the need for available and effective therapies (Lubian et al., 2016). Drops possibly can reduce depression, demonstrated via neurological alterations associated with improved emotional regulation and reductions in DASS-21 scores. Future research should attempt to develop interventions with highly accessible platforms, such as mobile Apps, to assess Drops effectiveness and applicability as treatments in larger samples. Thus, Drops can potentially be utilised in the development of required accessible and affordable treatments.

Additionally, Drops may be applied to aid negative emotions in those without a mental health diagnosis. Music can be easily obtained and accessed via platforms such as Apps, with limited adverse side effects unlike other treatments, such as medication, reducing adherence (Rheker, Winkler, Doering, & Rief, 2017; Thase & Schwartz, 2015). Thus, MT with Drops can be made available to those diagnosed and those requiring mental health aid without an official diagnosis (Mental Health Foundation, 2016). Also, MT containing Drops can be easily used by individuals when and if they need it. For instance, student exam stress associated with negative thinking and AG and STG activity could possibly be reduced with Drop MT (Kogler et al., 2015; Westbrook, Patsenko, Mumford, Abramson, & Davidson, 2018). Therefore, Drops within MT can potentially be applied to help emotional control across numerous situations and people.

Meanwhile, brain activity related to regular Drop apprehension overlaps with activity seen in dance. For instance, STG and PC activity occur within both music and dance apprehension (Batson, Migliarese, Soriano, Burdette, & Laurienti, 2014; Karpati, Giacosa, Foster, Penhune, & Hyde, 2017; Reason et al., 2016). This indicates Drops may be applied alongside other creative therapies, such as dance therapy to aid in emotive, neurological, and movement disorders, including Parkinson's disease (Batson et al., 2014; de Dreu, van der Wilk, Poppe, Kwakkel, & van Wegen, 2012; Lossing, Moore, & Zuhl, 2017).

Also, the unique brain activity evoked when hearing Drops can perhaps be applied to diagnosing disorders, including depression. Structural and functional activity alterations in regions, such as the SMG within disorders, including depression and bipolar, can predict the type and severity of disorders with 75% accuracy (Rubin-Falcone et al., 2018). Some researchers suggest brain functioning and connectivity differences are more accurate at classifying mental health disorders in young people then clinical measures (Chai et al., 2016).

Therefore, Drops may be helpful in diagnosing and understanding individual mental health disorders via their elicitation of brain activity.

Meanwhile, music's association with neuroplasticity and elicited brain activity demonstrates Drops potential use in brain damage and injury treatment (Wan & Schlaug, 2010). As Drops may easily induce activity in specific brain regions, including those in frontal, temporal and parietal lobes, repeated apprehension can possibly help rehabilitate activity around neuronal damage after incidents such as Stroke, brain injury and emotive disorders (Johansson, 2011; Altenmüller & Schlaug, 2012, respectively). Therefore, Drops in MT may also aid in neurological rehabilitation for brain damage or injury, due to music neuroplasticity.

In addition, Drops could be fundamental to modern forms of MT and appealing to the expanding number of young adults with mental health conditions (Office for National Statistics, 2017). Currently, MT's commonly apply less engaging classical music to younger generation treatments where Drops would perhaps be more appropriate (Kolb, 2001; Mulder, Bogt, Raaijmakers, Gabhainn, & Sikkema, 2010). Thus, interventions using Drops could become more relevant, accessible and enjoyable to young adults. This would result in engaged and motivated patients, facilitating more successful treatment (Maclean et al., 2000). It is important to update treatments, maintaining their appeal and appropriateness for patients. Thus, future interventions for young adults with mental health conditions could consider implementing Drops.

Lastly, Drops in MT can potentially be used alongside other forms of treatment to aid rehabilitation and co-morbid disorders. In life-changing illnesses, such as Parkinson's disease, Alzheimer's disease, brain injury, obsessive-compulsive disorder (OCD) and Stroke there are co-occurring mental health problems, including depression, anxiety and stress (Akhmadeeva, Magzhanov, Tayupova, Baitimerov, & Khidiyatova, 2018; de la Rubia Ortí et al., 2018; Ouellet et al., 2018; Raglio et al., 2017; Shiranibidabadi & Mehryar, 2015). Drops may aid the treatment for central diseases and co-morbid mental health disorders, improving overall rehabilitation, as reductions in depression increase treatment motivation and participation (Gardstrom et al., 2013; Maclean et al., 2000; Pedersen et al., 2017; Zhao et al., 2016). Thus, Drops can possibly be applied in the treatment of numerous disorders and particularly in diseases often exhibiting co-morbid mental health problems.

## 5.6 Conclusion

Overall, this research offers a novel insight into how repeated Drop apprehension can be applied to form a possible new MT for depression. It suggests that Drops, over similar music without Drops, evoke important emotive neuronal networks including the STG, SMG, ITG, IFG, AG, and PC. These networks then may improve positive emotions, emotional control and reduce depressive symptoms over two-weeks. Despite not being anticipated, these brain regions are perhaps elicited in response to processing the unique structure of Drops and relate to co-occurring positive effects on emotion, emotional regulation and depressive symptoms. However, Drops did not influence impaired WM abilities in depression. Future research should attempt to explore Drops effects in more detail with larger samples, establishing causation via stimulation, and assessing differences between musicians and non-musicians. With this and future research, Drops may have the potential to be applied as treatments for numerous disorders, including depression, anxiety, brain injury, and Parkinson’s disease for the growing number of young adults who require it.

# 6 References

Achterberg, P., Heilbron, J., Houtman, D., & Aupers, S. (2011). A cultural globalization of popular music? American, Dutch, French, and German popular music charts (1965 to 2006). American Behavioral Scientist, 55(5), 589-608. doi:10.1177/0002764211398081

Akhmadeeva, G. N., Magzhanov, R. V., Tayupova, G. N., Baitimerov, A. R., & Khidiyatova, I. M. (2018). Depression and anxiety in Parkinson’s disease. Neuroscience And Behavioral Physiology, 48(5), 636-640. doi:10.1007/s11055-018-0609-1

Albouy, P., Mattout, J., Bouet, R., Maby, E., Sanchez, G., Aguera, P. E., … Tillmann, B. (2014). Impaired pitch perception and memory in congenital amusia: The deficit starts in the auditory cortex. Brain, 136(5), 1639–1661. https://doi.org/10.1093/brain/awt082

Alloway, T. P., & Horton, J. C. (2016). Does working memory mediate the link between dispositional optimism and depressive symptoms? Applied Cognitive Psychology, 30(6), 1068–1072. https://doi.org/10.1002/acp.3272

Alluri, V., Toiviainen, P., Lund, T. E., Wallentin, M., Vuust, P., Nandi, A. K., … Brattico, E. (2013). From vivaldi to beatles and back: Predicting lateralized brain responses to music. NeuroImage, 83, 627–636. https://doi.org/10.1016/j.neuroimage.2013.06.064

Altenmüller, E., & Schlaug, G. (health 2012). Music, brain, and health: Exploring biological foundations of music's effects. In R. R. MacDonald, G. Kreutz, L. Mitchell, R. R. MacDonald, G. Kreutz, L. Mitchell (Eds.), Music, health, and wellbeing (pp. 12-24). New York, NY, US: Oxford University Press. doi:10.1093/acprof:oso/9780199586974.003.0002

Altenmüller, E., Siggel, S., Mohammadi, B., Samii, A., & Münte, T. *F*. (2014). Play it again, Sam: Brain correlates of emotional music recognition. Frontiers in Psychology, 5(FEB), 1–8. https://doi.org/10.3389/fpsyg.2014.00114

Angulo-Perkins, A., Aubé, W., Peretz, I., Barrios, *F*. A., Armony, J. L., & Concha, L. (2014). Music listening engages specific cortical regions within the temporal lobes: Differences between musicians and non-musicians. Cortex, 59, 126–137. https://doi.org/10.1016/j.cortex.2014.07.013

Arjmand, H. A., Hohagen, J., Paton, B., & Rickard, N. S. (2017). Emotional responses to music: Shifts in frontal brain asymmetry mark periods of musical change. Frontiers in Psychology, 8(DEC), 1–13. https://doi.org/10.3389/fpsyg.2017.02044

Bailey, J. A., Zatorre, R. J., & Penhune, V. B. (2014). Early musical training is linked to gray matter structure in the ventral premotor cortex and auditory-motor rhythm synchronization performance. Journal Of Cognitive Neuroscience, 26(4), 755-767. doi:10.1162/jocn_a_00527

Baird, A. D., Walker, D. G., Biggs, V., & Robinson, G. A. (2014). Selective preservation of the beat in apperceptive music agnosia: A case study. Cortex, 53(1), 27–33. https://doi.org/10.1016/j.cortex.2014.01.005

Barrett, *F*. S., & Janata, P. (2016). Neural responses to nostalgia-evoking music modeled by elements of dynamic musical structure and individual differences in affective traits. Neuropsychologia, 91, 234–246. https://doi.org/10.1016/j.neuropsychologia.2016.08.012

Batson, G., Migliarese, S. J., Soriano, C., Burdette, J. H., & Laurienti, P. J. (2014). Effects of improvisational dance on balance in Parkinson's disease: A two-phase fMRI case study. Physical & Occupational Therapy In Geriatrics, 32(3), 188-197. doi:10.3109/02703181.2014.927946

Baumgartner, T., Esslen, M., & Jäncke, L. (2006). From emotion perception to emotion experience: Emotions evoked by pictures and classical music. International Journal of Psychophysiology, 60(1), 34–43. https://doi.org/10.1016/j.ijpsycho.2005.04.007

Beaty, R. E. (2015). The neuroscience of musical improvisation. Neuroscience And Biobehavioral Reviews, 51108-117. doi:10.1016/j.neubiorev.2015.01.004

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. Cerebral Cortex, 10(3), 295–307. https://doi-org.chain.kent.ac.uk/10.1093/cercor/10.3.295

Belden, A. C., Pagliaccio, D., Murphy, E. R., Luby, J. L., & Barch, D. M. (2015). Neural activation during cognitive emotion regulation in previously depressed compared to healthy children: Evidence of specific alterations. Journal Of The American Academy Of Child & Adolescent Psychiatry, 54(9), 771-781. doi:10.1016/j.jaac.2015.06.014

Belfi, A. M., Evans, E., Heskje, J., Bruss, J., & Tranel, D. (2017). Musical anhedonia after focal brain damage. Neuropsychologia, 9729-37. doi:10.1016/j.neuropsychologia.2017.01.030

Bengtsson, S. L., Ullén, *F*., Henrik Ehrsson, H., Hashimoto, T., Kito, T., Naito, E., … Sadato, N. (2009). Listening to rhythms activates motor and premotor cortices. Cortex, 45(1), 62–71. https://doi.org/10.1016/j.cortex.2008.07.002

Besteher, B., Gaser, C., Langbein, K., Dietzek, M., Sauer, H., & Nenadić, I. (2017). Effects of subclinical depression, anxiety and somatization on brain structure in healthy subjects. Journal of Affective Disorders, 215(March), 111–117. https://doi.org/10.1016/j.jad.2017.03.039

Bhatti, A. M., Majid, M., Anwar, S. M., & Khan, B. (2016). Human emotion recognition and analysis in response to audio music using brain signals. Computers in Human Behavior, 65, 267–275. https://doi.org/10.1016/j.chb.2016.08.029

Bianchi, R., & Laurent, E. (2016). Altered short-term plasticity within the working memory neural network: Is it neuroticism or is it depression? Human Brain Mapping, 37(4), 1512–1513. https://doi.org/10.1002/hbm.23116

Bianco, R., Novembre, G., Keller, P. E., Kim, S. G., Scharf, *F*., Friederici, A. D., … Sammler, D. (2016). Neural networks for harmonic structure in music perception and action. NeuroImage, 142, 454–464. https://doi.org/10.1016/j.neuroimage.2016.08.025

Bieleninik, Ł., Geretsegger, M., Mössler, K., Assmus, J., Thompson, G., Gattino, G., & ... Gold, C. (2017). Effects of improvisational music therapy vs enhanced standard care on symptom severity among children with autism spectrum disorder: The TIME-A randomized clinical trial. JAMA: Journal Of The American Medical Association, 318(6), 525-535. doi:10.1001/jama.2017.9478

Bigliassi, M., León-Domínguez, U., & Altimari, L. R. (2015). How does the prefrontal cortex 'listen' to classical and techno music? A functional near-infrared spectroscopy (fNIRS) study. Psychology & Neuroscience, 8(2), 246-256. doi:10.1037/h0101064

Bishop, D. T., Karageorghis, C. I., & Loizou, G. (2007). A grounded theory of young tennis players' use of music to manipulate emotional state. Journal Of Sport & Exercise Psychology, 29(5), 584-607.

Bishop, D. T., Wright, M. J., & Karageorghis, C. I. (2014). Tempo and intensity of pre-task music modulate neural activity during reactive task performance. Psychology of Music, 42(5), 714–727. https://doi.org/10.1177/0305735613490595

Blood, A. J., Zatorre, R. J., Bermudez, P., & Evans, A. C. (1999). Emotional responses to pleasant and unpleasant music correlate with activity in paralimbic brain regions. Nature Neuroscience, 2(4), 382-387. doi:10.1038/7299

Bogert, B., Numminen-Kontti, T., Gold, B., Sams, M., Numminen, J., Burunat, I., … Brattico, E. (2016). Hidden sources of joy, fear, and sadness: Explicit versus implicit neural processing of musical emotions. Neuropsychologia, 89, 393–402. https://doi.org/10.1016/j.neuropsychologia.2016.07.005

Brattico, E., Alluri, V., Bogert, B., Jacobsen, T., Vartiainen, N., Nieminen, S., & Tervaniemi, M. (2011). A functional MRI study of happy and sad emotions in music with and without lyrics. Frontiers in Psychology, 2(DEC), 1–16. https://doi.org/10.3389/fpsyg.2011.00308

Bravo, *F*., Cross, I., Hawkins, S., Gonzalez, N., Docampo, J., Bruno, C., & Stamatakis, E. A. (2017). Neural mechanisms underlying valence inferences to sound: The role of the right angular gyrus. Neuropsychologia, 102(July 2016), 144–162. https://doi.org/10.1016/j.neuropsychologia.2017.05.029

Bray, S. R., Oliver, J. P., Graham, J. D., & Martin Ginis, K. A. (2013). Music, emotion, and self-control: Does listening to uplifting music replenish self-control strength for exercise? Journal of Applied Biobehavioral Research, 18(3), 156–173. https://doi.org/10.1111/jabr.12008

Brown, R. M., Chen, J. L., Hollinger, A., Penhune, V. B., Palmer, C., & Zatorre, R. J. (2013). Repetition suppression in auditory – motor regions to pitch and temporal structure in music. Journal of Cognitive Neuroscience, 313–328.

Brown, S., Martinez, M. J., Hodges, D. A., Fox, P. T., & Parsons, L. M. (2004). The song system of the human brain. Cognitive Brain Research, 20(3), 363–375. https://doi.org/10.1016/j.cogbrainres.2004.03.016

Buckner, R. L., Sepulcre, J., Talukdar, T., Krienen, *F*. M., Liu, H., Hedden, T., & ... Johnson, K. A. (2009). Cortical hubs revealed by intrinsic functional connectivity: Mapping, assessment of stability, and relation to Alzheimer's disease. The Journal Of Neuroscience, 29(6), 1860-1873. doi:10.1523/JNEUROSCI.5062-08.2009

Carta, M. G., Zairo, *F*., Saphino, D., Sevilla-Dedieu, C., Moro, M. *F*., Massidda, D., & Kovess, V. (2013). MDQ positive people's searching for effective and ineffective treatments for Bipolar Disorders: A screening study in France. Journal Of Affective Disorders, 149(1-3), 84-92. doi:10.1016/j.jad.2013.01.007

Chai, X. J., Hirshfeld-Becker, D., Biederman, J., Uchida, M., Doehrmann, O., Leonard, J. A., … Whitfield-Gabrieli, S. (2016). Altered intrinsic functional brain architecture in children at familial risk of Major Depression. Biological Psychiatry, 80(11), 849–858. https://doi.org/10.1016/j.biopsych.2015.12.003

Chen, J. L., Rae, C., & Watkins, K. E. (2012). Learning to play a melody: An fMRI study examining the formation of auditory-motor associations. NeuroImage, 59(2), 1200–1208. https://doi.org/10.1016/j.neuroimage.2011.08.012

Chen, X. J., Leith, H., Aarø, L. E., Manger, T., & Gold, C. (2016). Music therapy for improving mental health problems of offenders in correctional settings: systematic review and meta-analysis. Journal of Experimental Criminology, 12(2), 209–228. https://doi.org/10.1007/s11292-015-9250-y

Chu, B. C., Suveg, C., Creed, T. A., & Kendall, P. C. (2010). Involvement shifts, alliance ruptures, and managing engagement over therapy. In D. Castro-Blanco, M. S. Karver, D. Castro-Blanco, M. S. Karver (Eds.) , Elusive alliance: Treatment engagement strategies with high-risk adolescents (pp. 95-121). Washington, DC, US: American Psychological Association. doi:10.1037/12139-003

Chung, J., & Woods-Giscombe, C. (2016). Influence of dosage and type of music therapy in symptom management and rehabilitation for individuals with schizophrenia. Issues In Mental Health Nursing, 37(9), 631-641. doi:10.1080/01612840.2016.1181125

Cieri, *F*., Esposito, R., Cera, N., Pieramico, V., Tartaro, A., & di Giannantonio, M. (2017). Late-life depression: Modifications of brain resting state activity. Journal Of Geriatric Psychiatry And Neurology, 30(3), 140-150. doi:10.1177/0891988717700509

Clark, I. N., Baker, *F*. A., & Taylor, N. *F*. (2016). The modulating effects of music listening on health-related exercise and physical activity in adults: A systematic review and narrative synthesis. Nordic Journal Of Music Therapy, 25(1), 76-104. doi:10.1080/08098131.2015.1008558

Clément, S., Tonini, A., Khatir, *F*., Schiaratura, L., & Samson, S. (2012). Short and longer term effects of musical intervention in severe Alzheimer's disease. Music Perception, 29(5), 533-541. doi:10.1525/mp.2012.29.5.533

Conway, A. R. A., Kane, M. J., Bunting, M. *F*., Hambrick, *Z*. D., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. Psychonomic Bulletin & Review, 12(5), 769–786. https://doi.org/10.3758/BF03196772

Coombes, S. A., Corcos, D. M., Pavuluri, M. N., & Vaillancourt, D. E. (2012). Maintaining force control despite changes in emotional context engages dorsomedial prefrontal and premotor cortex. Cerebral Cortex, 22(3), 616–627. https://doi.org/10.1093/cercor/bhr141

Corbijn van Willenswaard, K., Lynn, *F*., McNeill, J., McQueen, K., Dennis, C., Lobel, M., & Alderdice, *F*. (2017). Music interventions to reduce stress and anxiety in pregnancy: A systematic review and meta-analysis. BMC Psychiatry, 17

Cowan, N. (2017). The many faces of working memory and short-term storage. Psychonomic Bulletin & Review, 24(4), 1158-1170. doi:10.3758/s13423-016-1191-6

Daly, I., Williams, D., Hallowell, J., Hwang, *F*., Kirke, A., Malik, A., … Nasuto, S. J. (2015). Music-induced emotions can be predicted from a combination of brain activity and acoustic features. Brain and Cognition, 101, 1–11. https://doi.org/10.1016/j.bandc.2015.08.003

de Dreu, M. J., van der Wilk, A. D., Poppe, E., Kwakkel, G., & van Wegen, E. H. (2012). Rehabilitation, exercise therapy and music in patients with Parkinson's disease: A meta-analysis of the effects of music-based movement therapy on walking ability, balance and quality of life. Parkinsonism & Related Disorders, 18(Suppl 1), S114-S119. doi:10.1016/S1353-8020(11)70036-0

de la Rubia Ortí, J. E., García-Pardo, M. P., Iranzo, C. C., Cerón Madrigal, J. J., Castillo, S. S., Rochina, M. J., & Prado Gascó, V. J. (2018). Does music therapy improve anxiety and depression in Alzheimer's patients?. The Journal Of Alternative And Complementary Medicine, 24(1), 33-36. doi:10.1089/acm.2016.0346

Deckersbach, T., Sl, R., Buhlmann, U., Mj, O., J-c, B., Nierenberg, A. A., … Dougherty, D. D. (2008). An fMRI investigation of working memory and sadness in females with bipolar disorder: A brief report An fMRI investigation of working memory and sadness in females with bipolar disorder: a brief report. Bipolar Disorders, 10(20), 928–942. https://doi.org/10.1111/j.1399-5618.2008.00633.x

DelDonno, S. R., Jenkins, L. M., Crane, N. A., Nusslock, R., Ryan, K. A., Shankman, S. A., … Langenecker, S. A. (2017). Affective traits and history of depression are related to ventral striatum connectivity. Journal of Affective Disorders, 221(October 2016), 72–80. https://doi.org/10.1016/j.jad.2017.06.014

Dillon, D. G., & Pizzagalli, D. A. (2018). Mechanisms of memory disruption in Depression. Trends in Neurosciences, 41(3), 137–149. https://doi.org/10.1016/j.tins.2017.12.006

Doeller, C. *F*., Opitz, B., Mecklinger, A., Krick, C., Reith, W., & Schröger, E. (2003). Prefrontal cortex involvement in preattentive auditory deviance detection: Neuroimaging and electrophysiological evidence. Neuroimage, 20(2), 1270-1282. doi:http://doi.org/10.1016/S1053-8119(03)00389-6

Dohn, A., Garza-Villarreal, E. A., Chakravarty, M. M., Hansen, M., Lerch, J. P., & Vuust, P. (2015). Gray-and white-matter anatomy of absolute pitch possessors. Cerebral Cortex, 25(5), 1379–1388. https://doi.org/10.1093/cercor/bht334

Dolcos, *F*., Labar, K. S., & Cabeza, R. (2004). Dissociable effects of arousal and valence on prefrontal activity indexing emotional evaluation and subsequent memory: An event-related fMRI study. NeuroImage, 23(1), 64–74. https://doi.org/10.1016/j.neuroimage.2004.05.015

Dumont, E., Syurina, E. V., Feron, *F*. M., & van Hooren, S. (2017). Music interventions and child development: A critical review and further directions. Frontiers In Psychology, 8doi:10.3389/fpsyg.2017.01694

Egermann, H., Fernando, N., Chuen, L., & McAdams, S. (2015). Music induces universal emotion-related psychophysiological responses: Comparing Canadian listeners to Congolese Pygmies. Frontiers In Psychology, 5doi:10.3389/fpsyg.2014.01341

Egermann H, McAdams S. 2013. Empathy and emotional contagion as a link between recognized and felt emotions in music listening. Music Percept 31:139–156.

Egermann, H., Sutherland, M. E., Grewe, O., Nagel, *F*., Kopiez, R., & Altenmüller, E. (2011). Does music listening in a social context alter experience? a physiological and psychological perspective on emotion. Musicae Scientiae, 15(3), 307–323. https://doi.org/10.1177/1029864911399497

Ellis, R. J., Bruijn, B., Norton, A. C., Winner, E., & Schlaug, G. (2013). Training-mediated leftward asymmetries during music processing: A cross-sectional and longitudinal fMRI analysis. NeuroImage, 75, 97–107. https://doi.org/10.1016/j.neuroimage.2013.02.045

Ellis, R. J., Norton, A. C., Overy, K., Winner, E., Alsop, D. C., & Schlaug, G. (2012). Differentiating maturational and training influences on fMRI activation during music processing. NeuroImage, 60(3), 1902–1912. https://doi.org/10.1016/j.neuroimage.2012.01.138

Ellis, R. J., & Simons, R. *F*. (2005). The impact of music on subjective and physiological indices of emotion while viewing films. Psychomusicology: A Journal Of Research In Music Cognition, 19(1), 15-40. doi:10.1037/h0094042

Erkkilä, J., Punkanen, M., Fachner, J., Ala-Ruona, E., Pöntiö, I., Tervaniemi, M., … Gold, C. (2011). Individual music therapy for depression: Randomised controlled trial. British Journal of Psychiatry, 199(2), 132–139. https://doi.org/10.1192/bjp.bp.110.085431

Fachner, J., Gold, C., & Erkkilä, J. (2013). Music therapy modulates fronto-temporal activity in rest-EEG in depressed clients. Brain Topography, 26(2), 338–354. https://doi.org/10.1007/s10548-012-0254-x

Fauvel, B., Groussard, M., Chételat, G., Fouquet, M., Landeau, B., Eustache, *F*., … Platel, H. (2014). Morphological brain plasticity induced by musical expertise is accompanied by modulation of functional connectivity at rest. NeuroImage, 90, 179–188. https://doi.org/10.1016/j.neuroimage.2013.12.065

Flores-Gutiérrez, E. O., Díaz, J. L., Barrios, *F*. A., Favila-Humara, R., Guevara, M. Á., del Río-Portilla, Y., & Corsi-Cabrera, M. (2007). Metabolic and electric brain patterns during pleasant and unpleasant emotions induced by music masterpieces. International Journal of Psychophysiology, 65(1), 69–84. https://doi.org/10.1016/j.ijpsycho.2007.03.004

Gagnepain, P., Fauvel, B., Desgranges, B., Gaubert, M., Viader, *F*., Eustache, *F*., … Platel, H. (2017). Musical expertise increases top–down modulation over hippocampal activation during familiarity decisions. Frontiers in Human Neuroscience, 11(September), 1–14. https://doi.org/10.3389/fnhum.2017.00472

García, P. J., Garcés, P., del Río, D., & Maestú, F. (2017). Tracking the effect of emotional distraction in working memory brain networks: Evidence from an MEG study. Psychophysiology, 54(11), 1726–1740. https://doi-org.chain.kent.ac.uk/10.1111/psyp.12912

Gardiner, J. C., & Horwitz, J. L. (2015). Neurologic music therapy and group psychotherapy for treatment of traumatic brain injury: Evaluation of a cognitive rehabilitation group. Music Therapy Perspectives, 33(2), 193-201. doi:10.1093/mtp/miu045

Gardstrom, S. C., Bartkowski, J., Willenbrink, J., & Diestelkamp, W. S. (2013). The impact of group music therapy on negative affect of people with co-occurring substance use disorders and mental illnesses. Music Therapy Perspectives, 31(2), 116-126. doi:10.1093/mtp/31.2.116

Garrido, S., & Schubert, E. (2015). Music and people with tendencies to depression. Music Perception, 32(4), 313-321. doi:10.1525/mp.2015.32.4.313

Garza-Villarreal, E. A., Jiang, *Z*., Vuust, P., Alcauter, S., Vase, L., Pasaye, E. H., … Barrios, *F*. A. (2015). Music reduces pain and increases resting state fMRI BOLD signal amplitude in the left angular gyrus in fibromyalgia patients. Frontiers in Psychology, 6(July), 1–11. https://doi.org/10.3389/fpsyg.2015.01051

Gold, C., Saarikallio, S., Crooke, A. H. D., & McFerran, K. S. (2017). Group music therapy as a preventive intervention for young people at risk: Cluster-randomized trial. Journal of Music Therapy, 54(2), 133–160. https://doi.org/10.1093/jmt/thx002

Gosselin, N., Peretz, I., Noulhiane, M., Hasboun, D., Beckett, C., Baulac, M., & Samson, S. (2005). Impaired recognition of scary music following unilateral temporal lobe excision. Brain: A Journal Of Neurology, 128(3), 628-640. doi:10.1093/brain/awh420

Grahn, J. A., & Schuit, D. (2012). Individual differences in rhythmic ability: Behavioral and neuroimaging investigations. Psychomusicology: Music, Mind, and Brain, 22(2), 105–121. https://doi.org/10.1037/a0031188

Grajny, K., Pyata, H., Spiegel, K., Lacey, E. H., Xing, S., Brophy, C., & Turkeltaub, P. E. (2016). Depression symptoms in chronic left hemisphere stroke are related to dorsolateral prefrontal cortex damage. The Journal Of Neuropsychiatry And Clinical Neurosciences, 28(4), 292-298.

Grau-Sánchez, J., Ramos, N., Duarte, E., Särkämö, T., & Rodríguez-Fornells, A. (2017). Time course of motor gains induced by music-supported therapy after stroke: An exploratory case study. Neuropsychology, 31(6), 624-635. doi:10.1037/neu0000355

Greene, C. M., Flannery, O., & Soto, D. (2014). Distinct parietal sites mediate the influences of mood, arousal, and their interaction on human recognition memory. Cognitive, Affective and Behavioral Neuroscience, 14(4), 1327–1339. https://doi.org/10.3758/s13415-014-0266-y

Grimm, T., & Kreutz, G. (2018). Music interventions in disorders of consciousness (DOC)—A systematic review. Brain Injury, 32(6), 704-714. doi:10.1080/02699052.2018.1451657

Grynberg, D., Davydov, D. M., Vermeulen, N., & Luminet, O. (2012). Alexithymia is associated with an augmenter profile, but not only: Evidence for anticipation to arousing music. Scandinavian Journal Of Psychology, 53(5), 375-381. doi:10.1111/j.1467-9450.2012.00962.x

Habibi, A., & Damasio, A. (2014). Music, feelings, and the human brain. Psychomusicology: Music, Mind, and Brain, 24(1), 92–102. https://doi.org/10.1037/pmu0000033

Haenfler, R. (2014). Review of music, style, and aging: Growing old disgracefully?. American Journal Of Sociology, 119(6), 1815-1817. doi:10.1086/676419

Hakvoort, L., Bogaerts, S., Thaut, M. H., & Spreen, M. (2015). Influence of music therapy on coping skills and anger management in forensic psychiatric patients: An exploratory study. International Journal Of Offender Therapy And Comparative Criminology, 59(8), 810-836. doi:10.1177/0306624X13516787

Han, H. J., Jung, W. H., Yun, J.-Y., Park, J. W., Cho, K. K., Hur, J.-W., … Kwon, J. S. (2016). Disruption of effective connectivity from the dorsolateral prefrontal cortex to the orbitofrontal cortex by negative emotional distraction in obsessive–compulsive disorder. Psychological Medicine, 46(5), 921–932. https://doi-org.chain.kent.ac.uk/10.1017/S0033291715002391

Harada, K., Ikuta, T., Nakashima, M., Watanuki, T., Hirotsu, M., Matsubara, T., … Matsuo, K. (2018). Altered connectivity of the anterior cingulate and the posterior superior temporal gyrus in a longitudinal study of later-life depression. Frontiers in Aging Neuroscience, 10(FEB), 1–11. https://doi.org/10.3389/fnagi.2018.00031

Health and Social Care Information Centre. (2015). Provisional monthly hospital episode statistics for admitted care, outpatients and A&E data, April 2013–October 2013: Topic of interest – Eating disorders. Retrieved from gov.uk/government/statistics/hes-for-admitted-patientcare-outpatient-and-ae-provisional-monthly-data-april- 2014-to-october-2014 [Accessed 23/08/16].

Heller, W. (1993). Neuropsychological mechanisms of individual differences in emotion, personality, and arousal. Neuropsychology 7, 476.

Henderson, S. E., Vallejo, A. I., Ely, B. A., Kang, G., Krain Roy, A., Pine, D. S., … Gabbay, V. (2014). The neural correlates of emotional face-processing in adolescent depression: A dimensional approach focusing on anhedonia and illness severity. Psychiatry Research - Neuroimaging, 224(3), 234–241. https://doi.org/10.1016/j.pscychresns.2014.09.006

Herholz, S. C., Halpern, A. R., & Zatorre, R. J. (2012). Neuronal correlates of perception, imagery, and memory for familiar tunes. Journal of Cognitive Neuroscience, 24(6), 1382–1397. https://doi.org/10.1162/jocn_a_00216

Herwig, U., Opialla, S., Cattapan, K., Wetter, T. C., Jäncke, L., & Brühl, A. B. (2018). Emotion introspection and regulation in depression. Psychiatry Research: Neuroimaging, 2777-13. doi:10.1016/j.pscychresns.2018.04.008

Hirel, C., Lévêque, Y., Deiana, G., Richard, N., Cho, T. H., Mechtouff, L., … Nighoghossian, N. (2014). Amusie acquise et anhédonie musicale. Revue Neurologique, 170(8), 536–540. https://doi.org/10.1016/j.neurol.2014.03.015

Hoenig, K., Müller, C., Herrnberger, B., Sim, E. J., Spitzer, M., Ehret, G., & Kiefer, M. (2011). Neuroplasticity of semantic representations for musical instruments in professional musicians. NeuroImage, 56(3), 1714–1725. https://doi.org/10.1016/j.neuroimage.2011.02.065

Hogue, J. D., Crimmins, A. M., & Kahn, J. H. (2016). “So sad and slow, so why can’t I turn off the radio”: The effects of gender, depression, and absorption on liking music that induces sadness and music that induces happiness. Psychology of Music, 44(4), 816–829. https://doi.org/10.1177/0305735615594489

Hou, Z., Kong, Y., He, X., Yin, Y., Zhang, Y., & Yuan, Y. (2018). Increased temporal variability of striatum region facilitating the early antidepressant response in patients with major depressive disorder. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 85(November 2017), 39–45. https://doi.org/10.1016/j.pnpbp.2018.03.026

Hou, J., Song, B., Chen, A. N., Sun, C., Zhou, J., Zhu, H., & Beauchaine, T. P. (2017). Review on neural correlates of emotion regulation and music: Implications for emotion dysregulation. Frontiers In Psychology, 8

Hudziak, J. J., Albaugh, M. D., Ducharme, S., Karama, S., Spottswood, M., Crehan, E., & ... Botteron, K. N. (2014). Cortical thickness maturation and duration of music training: Health-promoting activities shape brain development. Journal Of The American Academy Of Child & Adolescent Psychiatry, 53(11), 1153-1161. doi:10.1016/j.jaac.2014.06.015

Huron, D. (2006). Sweet anticipation: Music and the psychology of expectation. Cambridge, MA, US: The MIT Press.

Huron, D. (2011). Why is sad music pleasurable? A possible role for prolactin. Musicae Scientiae, 15(2), 146-158. doi:10.1177/1029864911401171

Iyendo, T. O. (2016). Exploring the effect of sound and music on health in hospital settings: A narrative review. International Journal of Nursing Studies, 63, 82–100. https://doi.org/10.1016/j.ijnurstu.2016.08.008

Jang, I., Kim, G., & Jeong, G. (2017). Neuroanatomical assessment of the impact of negative emotion on explicit memory in patients with obsessive-compulsive disorder. Neuroreport: For Rapid Communication Of Neuroscience Research, 28(1), 1-9. doi:10.1097/WNR.0000000000000707

Jayaweera, H. K., Hickie, I. B., Duffy, S. L., Mowszowski, L., Norrie, L., Lagopoulos, J., & Naismith, S. L. (2016). Episodic memory in depression: The unique contribution of the anterior caudate and hippocampus. Psychological Medicine, 46(10), 2189-2199. doi:10.1017/S0033291716000787

Johansson, B. B. (2011). Current trends in stroke rehabilitation. A review with focus on brain plasticity. Acta Neurologica Scandinavica, 123(3), 147-159. doi:10.1111/j.1600-0404.2010.01417.x

Jones, N. P., Fournier, J. C., & Stone, L. B. (2017). Neural correlates of autobiographical problem-solving deficits associated with rumination in depression. Journal of Affective Disorders, 218(April), 210–216. https://doi.org/10.1016/j.jad.2017.04.069

Joucla, C., Nicolier, M., Giustiniani, J., Brunotte, G., Noiret, N., Monnin, J., … Gabriel, D. (2018). Evidence for a neural signature of musical preference during silence. International Journal of Psychophysiology, 125(February), 50–56. https://doi.org/10.1016/j.ijpsycho.2018.02.007

Jung, X. T., & Newton, R. (2009). Cochrane reviews of non-medication-based psychotherapeutic and other interventions for schizophrenia, psychosis, and bipolar disorder: A systematic literature review. International Journal Of Mental Health Nursing, 18(4), 239-249. doi:10.1111/j.1447-0349.2009.00613.x

Juslin, P. N., & Vastfjall, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. Behav. Brain Sci., 31(5), 559--+. https://doi.org/10.1017/s0140525x08005293

Karim, H. T., Andreescu, C., Tudorascu, D., Smagula, S. *F*., Butters, M. A., Karp, J. *F*., … Aizenstein, H. J. (2017). Intrinsic functional connectivity in late-life depression: Trajectories over the course of pharmacotherapy in remitters and non-remitters. Molecular Psychiatry, 22(3), 450–457. https://doi.org/10.1038/mp.2016.55

Karpati, *F*. J., Giacosa, C., Foster, N. E. V., Penhune, V. B., & Hyde, K. L. (2017). Dance and music share gray matter structural correlates. Brain Research, 1657, 62–73. https://doi.org/10.1016/j.brainres.2016.11.029

Katlowitz, K. A., Oya, H., Howard, M. A., Greenlee, J. D. W., & Long, M. A. (2017). Paradoxical vocal changes in a trained singer by focally cooling the right superior temporal gyrus. Cortex, 89, 111–119. https://doi.org/10.1016/j.cortex.2017.01.024

Kavak, *F*., Ünal, S., & Yılmaz, E. (2016). Effects of relaxation exercises and music therapy on the psychological symptoms and depression levels of patients with schizophrenia. Archives Of Psychiatric Nursing, 30(5), 508-512. doi:10.1016/j.apnu.2016.05.003

Kayashima, Y., Yamamuro, K., Makinodan, M., Nakanishi, Y., Wanaka, A., & Kishimoto, T. (2017). Effects of canon chord progression on brain activity and motivation are dependent on subjective feelings, not the chord progression per se. Neuropsychiatric Disease and Treatment, 13, 1499–1508. https://doi.org/10.2147/NDT.S136815

Keough, L. A., King, B., & Lemmerman, T. (2017). Assessment-based small-group music therapy programming for individuals with dementia and Alzheimer’s disease: A multi-year clinical project. Music Therapy Perspectives, 35(2), 182-189.

Kercher, K. (1992). Assessing subjective well-being in the old-old: The PANAS as a measure of orthogonal dimensions of positive and negative affect. Research On Aging, 14(2), 131-168. doi:10.1177/0164027592142001

Kerer, M., Marksteiner, J., Hinterhuber, H., Kemmler, G., Bliem, H. R., & Weiss, E. M. (2014). Happy and sad judgements in dependence on mode and note density in patients with mild cognitive impairment and early-stage Alzheimer's disease. Gerontology, 60(5), 402-412. doi:10.1159/000358010

Kerestes, R., Ladouceur, C. D., Med, S., Nathan, P. J., Blumberg, H. P., Maloney, K., … Phillips, M. L. (2012). Abnormal prefrontal activity subserving attentional control of emotion in remitted depressed patients during a working memory task with emotional distracters. Psychological Medicine, 42(1), 31–40. https://doi-org.chain.kent.ac.uk/10.1017/S0033291711001097

Khalfa, S., Guye, M., Peretz, I., Chapon, *F*., Girard, N., Chauvel, P., & Bogert, C. (2008). Evidence of lateralized anteromedial temporal structures involvement in musical emotion processing. Neuropsychologia, 46(10), 2485–2493. https://doi.org/10.1016/j.neuropsychologia.2008.04.009

Kim, J., Schultz, J., Rohe, T., Wallraven, C., Lee, S., & Bülthoff, H. H. (2015). Abstract representations of associated emotions in the human brain. The Journal Of Neuroscience, 35(14), 5655-5663. doi:10.1523/JNEUROSCI.4059-14.2015

Klineburger, P. C., & Harrison, D. W. (2015). The dynamic functional capacity theory: A neuropsychological model of intense emotions. Cogent Psychology, 2(1), doi:10.1080/23311908.2015.1029691

Klinke, M. E., Hafsteinsdóttir, T. B., Hjaltason, H., & Jónsdóttir, H. (2015). Ward-based interventions for patients with hemispatial neglect in stroke rehabilitation: A systematic literature review. International Journal Of Nursing Studies, 52(8), 1375-1403. doi:10.1016/j.ijnurstu.2015.04.004

Koch, K., Stegmaier, S., Schwarz, L., Erb, M., Reinl, M., Scheffler, K., … Ethofer, T. (2018). Neural correlates of processing emotional prosody in unipolar depression. Hum.Brain Mapp., 39(1065–9471 (Linking)), 3419–3427. https://doi.org/10.1002/hbm.24185

Koelsch, S. (2006). Significance of Broca’s area and ventral premotor cortex for music-syntactic processing. Cortex, 42(4), 518–520. https://doi.org/10.1016/S0010-9452(08)70390-3

Koelsch, S. (2014). Brain correlates of music-evoked emotions. Nature Reviews Neuroscience, 15(3), 170–180. https://doi.org/10.1038/nrn3666

Koelsch, S., Fritz, T., Cramon, D. Y. V., Müller, K., & Friederici, A. D. (2006). Investigating emotion with music: An fMRI study. Human Brain Mapping, 27(3), 239–250. https://doi.org/10.1002/hbm.20180

Koelsch, S., Fritz, T., & Schlaug, G. (2008). Amygdala activity can be modulated by unexpected chord functions during music listening. Neuroreport: For Rapid Communication Of Neuroscience Research, 19(18), 1815-1819. doi:10.1097/WNR.0b013e32831a8722

Koelsch, S., & Siebel, W. A. (2005). Towards a neural basis of music perception. Trends In Cognitive Sciences, 9(12), S78-S84. doi:10.1016/j.tics.2005.10.001

Koelsch, S., Skouras, S., Fritz, T., Herrera, P., Bonhage, C., Küssner, M. B., & Jacobs, A. M. (2013). The roles of superficial amygdala and auditory cortex in music-evoked fear and joy. Neuroimage, 8149-60. doi:10.1016/j.neuroimage.2013.05.008

Kogler, L., Müller, V. I., Chang, A., Eickhoff, S. B., Fox, P. T., Gur, R. C., & Derntl, B. (2015). Psychosocial versus physiological stress—Meta-analyses on deactivations and activations of the neural correlates of stress reactions. Neuroimage, 119235-251. doi:10.1016/j.neuroimage.2015.06.059

Kolb, B. M. (2001). The effect of generational change on classical music concert attendance and orchestras' responses in the UK and US. Cultural Trends (Vol. 11). https://doi.org/10.1080/09548960109365147

Komosinski, M., & Mensfelt, A. (2016). Emotions perceived and emotions experienced in response to computer-generated music. Music Perception, 33(4), 432-445. doi:10.1525/mp.2016.33.4.432

Koneĉni, V. J. (2008). Does Music Induce Emotion? A Theoretical and Methodological Analysis. Psychology of Aesthetics, Creativity, and the Arts, 2(2), 115–129. https://doi.org/10.1037/1931-3896.2.2.115

Kornysheva, K., von Anshelm-Schiffer, A. M., & Schubotz, R. I. (2011). Inhibitory stimulation of the ventral premotor cortex temporarily interferes with musical beat rate preference. Human Brain Mapping, 32(8), 1300–1310. https://doi.org/10.1002/hbm.21109

Kornysheva, K., Von Cramon, D. Y., Jacobsen, T., & Schubotz, R. I. (2010). Tuning-in to the beat: Aesthetic appreciation of musical rhythms correlates with a premotor activity boost. Human Brain Mapping, 31(1), 48–64. https://doi.org/10.1002/hbm.20844

Kreutz, G., Russ, M. O., Bongard, S., & Lanfermann, H. (2003). Cerebral correlates of music listening. An fMRI-study on the effects of "happy" and "sad" classical music. Nervenheilkunde, 22(3), 150–156.

Kunert, R., Willems, R. M., Casasanto, D., Patel, A. D., & Hagoort, P. (2015). Music and language syntax interact in Broca's area: An fMRI study. PLoS ONE, 10(11). Retrieved from http://search.ebscohost.com.chain.kent.ac.uk/login.aspx?direct=true&db=psyh&AN=2015-52660-001&site=ehost-live

Lai, C. H., Wu, Y. Te, & Hou, Y. M. (2017). Functional network-based statistics in depression: Theory of mind subnetwork and importance of parietal region. Journal of Affective Disorders, 217(539), 132–137. https://doi.org/10.1016/j.jad.2017.03.073

Lappe, C., Steinsträter, O., & Pantev, C. (2013). Rhythmic and melodic deviations in musical sequences recruit different cortical areas for mismatch detection. Frontiers in Human Neuroscience, 7(June), 1–9. https://doi.org/10.3389/fnhum.2013.00260

Lee, S. E., Han, Y., & Park, H. (2016a). Neural activations of guided imagery and music in negative emotional processing: A functional MRI study. Journal of Music Therapy, 53(3), 257–278. https://doi.org/10.1093/jmt/thw007

Lee, K. S., Jeong, H. C., Yim, J. E., & Jeon, M. Y. (2016b). Effects of music therapy on the cardiovascular and autonomic nervous system in stress-induced university students: A randomized controlled trial. The Journal Of Alternative And Complementary Medicine, 22(1), 59-65. doi:10.1089/acm.2015.0079

Lee, Y. J., Kim, S., Gwak, A. R., Kim, S. J., Kang, S. G., Na, K. S., … Park, J. (2016c). Decreased regional gray matter volume in suicide attempters compared to suicide non-attempters with major depressive disorders. Comprehensive Psychiatry, 67, 59–65. https://doi.org/10.1016/j.comppsych.2016.02.013

Lega, C., Stephan, M. A., Zatorre, R. J., & Penhune, V. (2016). Testing the role of dorsal premotor cortex in auditory-motor association learning using Transcranical Magnetic Stimulation (TMS). PLoS ONE, 11(9), 1–17. https://doi.org/10.1371/journal.pone.0163380

Lehne, M., Rohrmeier, M., & Koelsch, S. (2014). Tension-related activity in the orbitofrontal cortex and amygdala: An fMRI study with music. Social Cognitive and Affective Neuroscience, 9(10), 1515–1523. https://doi.org/10.1093/scan/nst141

Leonardi, S., Cacciola, A., De Luca, R., Aragona, B., Andronaco, V., Milardi, D., & ... Calabrò, R. S. (2018). The role of music therapy in rehabilitation: Improving aphasia and beyond. International Journal Of Neuroscience, 128(1), 90-99. doi:10.1080/00207454.2017.1353981

Lesiuk, T. (2015). The effect of mindfulness-based music therapy on attention and mood in women receiving adjuvant chemotherapy for breast cancer: A pilot study. Oncology Nursing Forum, 42(3), 276-282.

Levitin, D. J., & Menon, V. (2005). The Neural Locus of Temporal Structure and Expectancies in Music: Evidence From Functional Neuroimaging At 3 Tesla. Music Perception: An Interdisciplinary Journal, 22(3), 563–575. https://doi.org/10.1525/mp.2005.22.3.563

Li, C. W., Chen, J. H., & Tsai, C. G. (2015). Listening to music in a risk-reward context: The roles of the temporoparietal junction and the orbitofrontal/insular cortices in reward-anticipation, reward-gain, and reward-loss. Brain Research, 1629(1), 160–170. https://doi.org/10.1016/j.brainres.2015.10.024

Li, H., Wei, D., Sun, J., Zhang, Q., & Qiu, J. (2017). Fronto-limbic alterations in negatively biased attention in young adults with subthreshold depression. Frontiers in Psychology, 8(AUG), 1–10. https://doi.org/10.3389/fpsyg.2017.01354

Li, M., Xu, H., & Lu, S. (2018). Neural basis of depression related to a dominant right hemisphere: A resting-state fMRI study. Behavioural Neurology, 2018

Lossing, A., Moore, M., & Zuhl, M. (2017). Dance as a treatment for neurological disorders. Body, Movement And Dance In Psychotherapy, 12(3), 170-184. doi:10.1080/17432979.2016.1260055

Lovibond, S.H. & Lovibond, P.*F*. (1995). Manual for the Depression Anxiety & Stress Scales. (2nd Ed.) Sydney: Psychology Foundation.

Lubian, K., Weich, S., Stansfeld, S., Bebbington, P., Brugha, T., Spiers, N., … Cooper, C. (2016). Chapter 3: Mental health treatment and services. In S. McManus, P. Bebbington, R. Jenkins, & T. Brugha (Eds.), Mental health and wellbeing in England: Adult Psychiatric Morbidity Survey 2014. Leeds: NHS Digital.

Luck, G. (2014). Music and emotion: Empirical and theoretical perspectives. Musicae Scientiae, 18(3), 255. https://doi.org/10.1177/1029864914543751

Machado, L., & Cantilino, A. (2017). A systematic review of the neural correlates of positive emotions. Revista Brasileira De Psiquiatria, 39(2), 172-179. doi:10.1590/1516-4446-2016-1988

Mackinnon, A., Jorm, A. *F*., Christensen, H., Korten, A. E., Jacomb, P. A., & Rodgers, B. (1999). A short form of the Positive and Negative Affect Schedule: Evaluation of factorial validity and invariance across demographic variables in a community sample. Personality And Individual Differences, 27(3), 405-416. doi:10.1016/S0191-8869(98)00251-7

Maclean, N., Pound, P., Wolfe, C., & Rudd, A. (2000). Qualitative analysis of stroke patients' motivation for rehabilitation. BMJ: British Medical Journal, 321(7268), 1051-1054. doi:10.1136/bmj.321.7268.1051

Mago, R., Fagiolini, A., Weiller, E., & Weiss, C. (2018). Understanding the emotions of patients with inadequate response to antidepressant treatments: Results of an international online survey in patients with major depressive disorder. BMC Psychiatry, 18

Marchant, N. L., & Howard, R. J. (2015). Cognitive Debt and Alzheimer’s disease. Journal Of Alzheimer's Disease, 44(3), 755-770.

Matsui, T., Tanaka, S., Kazai, K., Tsuzaki, M., & Katayose, H. (2013). Activation of the left superior temporal gyrus of musicians by music-derived sounds. NeuroReport, 24(1), 41–45. https://doi.org/10.1097/WNR.0b013e32835c1e02

McCaffrey, T., & Edwards, J. (2016). “music therapy helped me get back doing”: Perspectives of music therapy participants in mental health services. Journal of Music Therapy, 53(2), 121–148. https://doi.org/10.1093/jmt/thw002

McCrone, P., Dhanasiri, S., Patel, A., Knapp, M., & Lawton-Smith, S. (2008). Paying the price: The cost of mental health care in england to 2026. London: King's Fund

McDonald, I. (2006). Musical alexia with recovery: A personal account. Brain, 129(10), 2554–2561. https://doi.org/10.1093/brain/awl235

McManus, S., Hassiotis, A., Jenkins, R., Dennis, M., Aznar, C., & Appleby, L. (2016). Chapter 12: Suicidal thoughts, suicide attempts, and self-harm. In S. McManus, P.

Bebbington, R. Jenkins, & T. Brugha (Eds.), Mental health and wellbeing in England: Adult Psychiatric Morbidity Survey 2014. Leeds: NHS Digital.

Foundation, M. H. Fundamental Facts About Mental Health 2016. (Mental Health Foundation, London, 2016).

Meyer LB. 1956. Emotion and meaning in music. Chicago: Chicago University Press.

Mikutta, C., Altorfer, A., Strik, W., & Koenig, T. (2012). Emotions, arousal, and frontal alpha rhythm asymmetry during Beethoven's 5th symphony. Brain Topography, 25(4), 423-430. doi:10.1007/s10548-012-0227-0

Mikutta, C. A., Dürschmid, S., Bean, N., Lehne, M., Lubell, J., Altorfer, A., & ... Koelsch, S. (2015). Amygdala and orbitofrontal engagement in breach and resolution of expectancy: A case study. Psychomusicology: Music, Mind, And Brain, 25(4), 357-365. doi:10.1037/pmu0000121

Mitterschiffthaler, M. T., Fu, C. H. Y., Dalton, J. A., Andrew, C. M., & Williams, S. C. R. (2007). A functional MRI study of happy and sad affective states induced by classical music. Human Brain Mapping, 28(11), 1150–1162. https://doi.org/10.1002/hbm.20337

Miu, A. C., Piţur, S., & Szentágotai-Tătar, A. (2016). Aesthetic emotions across arts: A comparison between painting and music. Frontiers In Psychology, 6

Misuraca, R., Miceli, S., & Teuscher, U. (2017). Three effective ways to nurture our brain: Physical activity, healthy nutrition, and music. A review. European Psychologist, 22(2), 101-120. doi:10.1027/1016-9040/a000284

Moore., K, S. (2013). A systematic review on the neural effects of music on emotion regulation: Implications for music therapy practice. Journal of Music Therapy, 50(3) 198–242.

Mori, K., & Iwanaga, M. (2014). Pleasure generated by sadness: Effect of sad lyrics on the emotions induced by happy music. Psychology Of Music, 42(5), 643-652. doi:10.1177/0305735613483667

Mualem, O., & Lavidor, M. (2015). Music education intervention improves vocal emotion recognition. International Journal of Music Education, 33(4), 413–425. https://doi.org/10.1177/0255761415584292

Mulder, J., Ter Bogt, T. M., Raaijmakers, Q. W., Gabhainn, S. N., & Sikkema, P. (2010). From death metal to R&B? Consistency of music preferences among Dutch adolescents and young adults. Psychology Of Music, 38(1), 67-83. doi:10.1177/0305735609104349

Nagel, J. J., & Bradshaw, S. (2013). Coda: Psychoanalysis and music in the psyche and society. International Journal Of Applied Psychoanalytic Studies, 10(2), 147-151. doi:10.1002/aps.1357

Nan, Y., & Friederici, A. D. (2013). Differential roles of right temporal cortex and broca's area in pitch processing: Evidence from music and mandarin. Human Brain Mapping, 34(9), 2045–2054. https://doi.org/10.1002/hbm.22046

Nan, Y., Knösche, T. R., Zysset, S., & Friedend, A. D. (2008). Cross-cultural music phrase processing: An fMRI study. Human Brain Mapping, 29(3), 312–328. https://doi.org/10.1002/hbm.20390

Nune Nikoghosyan., (2014). Music, Style, and Aging: Growing Old Disgracefully?, Popular Music and Society, 38(2), 263-265, doi:10.1080/03007766.2014.888169

Nusbaum, E. C., Silvia, P. J., Beaty, R. E., Burgin, C. J., Hodges, D. A., & Kwapil, T. R. (2014). Listening between the notes: Aesthetic chills in everyday music listening. Psychology Of Aesthetics, Creativity, And The Arts, 8(1), 104-109. doi:10.1037/a0034867

Oetken, S., Pauly, K. D., Gur, R. C., Schneider, *F*., Habel, U., & Pohl, A. (2017). Don't worry, be happy - Neural correlates of the influence of musically induced mood on self-evaluation. Neuropsychologia, 100(April), 26–34. https://doi.org/10.1016/j.neuropsychologia.2017.04.010

Office for National Statistics., (2017). Measuring national well-being: Life in the UK, Apr 2017. Found at: https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/measuringnationalwellbeing/apr2017

Omar, R., Henley, S. M. D., Bartlett, J. W., Hailstone, J. C., Gordon, E., Sauter, D. A., … Warren, J. D. (2011). The structural neuroanatomy of music emotion recognition: Evidence from frontotemporal lobar degeneration. NeuroImage, 56(3), 1814–1821. https://doi.org/10.1016/j.neuroimage.2011.03.002

Omigie, D. (2016). Basic, specific, mechanistic? Conceptualizing musical emotions in the brain. Journal of Comparative Neurology, 524(8), 1676–1686. https://doi.org/10.1002/cne.23854

Omigie D, Pearce MT, Williamson VJ, Stewart L. 2013. Electrophysiological correlates of melodic processing in congenital amusia. Neuropsychologia 51:1749–1762.

Ono, K., Altmann, C. *F*., Matsuhashi, M., Mima, T., & Fukuyama, H. (2015). Neural correlates of perceptual grouping effects in the processing of sound omission by musicians and nonmusicians. Hearing Research, 319, 25–31. https://doi.org/10.1016/j.heares.2014.10.013

Osnes, B., Hugdahl, K., Hjelmervik, H., & Specht, K. (2012). Stimulus expectancy modulates inferior frontal gyrus and premotor cortex activity in auditory perception. Brain and Language, 121(1), 65–69. https://doi.org/10.1016/j.bandl.2012.02.002

Ouellet, M., Beaulieu-Bonneau, S., Sirois, M., Savard, J., Turgeon, A. *F*., Moore, L., & ... Laviolette, V. (2018). Depression in the first year after traumatic brain injury. Journal Of Neurotrauma, 35(14), 1620-1629. doi:10.1089/neu.2017.5379

Palazzi, A., Nunes, C. C., & Piccinini, C. A. (2018). Music therapy and musical stimulation in the context of prematurity: A narrative literature review from 2010–2015. Journal Of Clinical Nursing, 27(1-2), e1-e20. doi:10.1111/jocn.13893

Panksepp, J. (1995). The emotional sources of 'chills' induced by music. Music Perception, 13(2), 171-207. doi:10.2307/4028569

Panksepp, J. (2009). The emotional antecedents to the evolution of music and language. Musicae Scientiae, 13(2_suppl), 229–259. https://doi.org/10.1177/1029864909013002111

Pannese, A., Rappaz, M. A., & Grandjean, D. (2016). Metaphor and music emotion: Ancient views and future directions. Consciousness and Cognition, 44, 61–71. https://doi.org/10.1016/j.concog.2016.06.015

Pavlov, A., Kameg, K., Cline, T. W., Chiapetta, L., Stark, S., & Mitchell, A. M. (2017). Music therapy as a nonpharmacological intervention for anxiety in patients with a thought disorder. Issues In Mental Health Nursing, 38(3), 285-288.

Pavlova, E. L., Menshikova, A. A., Semenov, R. V., Bocharnikova, E. N., Gotovtseva, G. N., Druzhkova, T. A., & ... Guekht, A. B. (2018). Transcranial direct current stimulation of 20- and 30-minutes combined with sertraline for the treatment of depression. Progress In Neuro-Psychopharmacology & Biological Psychiatry, 8231-38. doi:10.1016/j.pnpbp.2017.12.004

Pedersen, S. A., Andersen, P. N., Lugo, R. G., Andreassen, M., & Sütterlin, S. (2017). Effects of music on agitation in dementia: A meta-analysis. Frontiers In Psychology, 8

Perlman, G., Bartlett, E., DeLorenzo, C., Weissman, M., McGrath, P., Ogden, T., … Parsey, R. (2017). Cortical thickness is not associated with current depression in a clinical treatment study. Human Brain Mapping, 38(9), 4370–4385. https://doi.org/10.1002/hbm.23664

Peters, A. T., Van Meter, A., Pruitt, P. J., Briceño, E. M., Ryan, K. A., Hagan, M., & ... Langenecker, S. A. (2016). Acute cortisol reactivity attenuates engagement of fronto-parietal and striatal regions during emotion processing in negative mood disorders. Psychoneuroendocrinology, 7367-78. doi:10.1016/j.psyneuen.2016.07.215

Phillips, J. L., Batten, L. A., Tremblay, P., Aldosary, *F*., & Blier, P. (2015). A prospective, longitudinal study of the effect of remission on cortical thickness and hippocampal volume in patients with treatment-resistant depression. International Journal of Neuropsychopharmacology, 18(8), 1–9. https://doi.org/10.1093/ijnp/pyv037

Piccirilli, M., Sciarma, T., & Luzzi, S. (2000). Modularity of music: Evidence from a case of pure amusia. Journal of Neurology Neurosurgery and Psychiatry, 69(4), 541–545. https://doi.org/10.1136/jnnp.69.4.541

Plailly, J., Tillmann, B., & Royet, J. P. (2007). The feeling of familiarity of music and odors: The same neural signature? Cerebral Cortex, 17(11), 2650–2658. https://doi.org/10.1093/cercor/bhl173

Platel, H., Price, C., Baron, J. C., Wise, R., Lambert, J., Frackowiak, R. S., … Eustache, *F*. (1997). The structural components of music perception. A functional anatomical study. Brain : A Journal of Neurology, 120 ( Pt 2, 229–243. https://doi.org/10.1093/brain/120.2.229

Potes, C., Gunduz, A., Brunner, P., & Schalk, G. (2012). Dynamics of electrocorticographic (ECoG) activity in human temporal and frontal cortical areas during music listening. NeuroImage, 61(4), 841–848. https://doi.org/10.1016/j.neuroimage.2012.04.022

Punkanen, M., Eerola, T., & Erkkilä, J. (2011). Biased emotional recognition in depression: Perception of emotions in music by depressed patients. Journal of Affective Disorders, 130(1–2), 118–126. https://doi.org/10.1016/j.jad.2010.10.034

Raglio, A., Galandra, C., Sibilla, L., Esposito, *F*., Gaeta, *F*., Di Salle, *F*., … Imbriani, M. (2016). Effects of active music therapy on the normal brain: fMRI based evidence. Brain Imaging and Behavior, 10(1), 182–186. https://doi.org/10.1007/s11682-015-9380-x

Raglio, A., Zaliani, A., Baiardi, P., Bossi, D., Sguazzin, C., Capodaglio, E., & ... Imbriani, M. (2017). Active music therapy approach for stroke patients in the post-acute rehabilitation. Neurological Sciences, 38(5), 893-897. doi:10.1007/s10072-017-2827-7

Randall, W. M., Rickard, N. S., & Vella-Brodrick, D. A. (2014). Emotional outcomes of regulation strategies used during personal music listening: A mobile experience sampling study. Musicae Scientiae, 18(3), 275–291. https://doi.org/10.1177/1029864914536430

Reason, M., Jola, C., Kay, R., Reynolds, D., Kauppi, J. P., Grobras, M. H., … Pollick, *F*. E. (2016). Spectators' aesthetic experience of sound and movement in dance performance: A transdisciplinary investigation. Psychology of Aesthetics, Creativity, and the Arts, 10(1), 42–55. https://doi.org/10.1037/a0040032

Renner, *F*., Siep, N., Arntz, A., van de Ven, V., Peeters, *F*. P. M. L., Quaedflieg, C. W. E. M., & Huibers, M. J. H. (2017). Negative mood-induction modulates default mode network resting-state functional connectivity in chronic depression. Journal of Affective Disorders, 208(September 2016), 590–596. https://doi.org/10.1016/j.jad.2016.10.022

Rheker, J., Winkler, A., Doering, B. K., & Rief, W. (2017). Learning to experience side effects after antidepressant intake—Results from a randomized, controlled, double-blind study. Psychopharmacology, 234(3), 329-338. doi:10.1007/s00213-016-4466-8

Rogenmoser, L., Zollinger, N., Elmer, S., & Jäncke, L. (2016). Independent component processes underlying emotions during natural music listening. Social Cognitive and Affective Neuroscience, 11(9), 1428–1439. https://doi.org/10.1093/scan/nsw048

Rolvsjord, R. (2015). Five episodes of clients' contributions to the therapeutic relationship: a qualitative study in adult mental health care. Nordic Journal of Music Therapy, 8131(October), 1–26. https://doi.org/10.1080/08098131.2015.1010562

Royal, I., Vuvan, D. T., Zendel, B. R., Robitaille, N., Schönwiesner, M., & Peretz, I. (2016). Activation in the right inferior parietal lobule reflects the representation of musical structure beyond simple pitch discrimination. PLoS ONE, 11(5), 1–15. https://doi.org/10.1371/journal.pone.0155291

Rubin-Falcone, H., Zanderigo, *F*., Thapa-Chhetry, B., Lan, M., Miller, J. M., Sublette, M. E., … Mann, J. J. (2018). Pattern recognition of magnetic resonance imaging-based gray matter volume measurements classifies bipolar disorder and major depressive disorder. Journal of Affective Disorders, 227(November 2017), 498–505. https://doi.org/10.1016/j.jad.2017.11.043

Sachs, M. E., Ellis, R. J., Schlaug, G., & Loui, P. (2016). Brain connectivity reflects human aesthetic responses to music. Social Cognitive and Affective Neuroscience, 11(6), 884–891. https://doi.org/10.1093/scan/nsw009

Şalçini, C., Sayar, G. H., Çebi, M., Tan, O., Kağan, G., Tanrıdağ, O., & Tarhan, N. (2018). The impact of high-frequency repetitive transcranial magnetic stimulation on executive functioning of drug-free patients with treatment-resistant depression. Psychiatry And Clinical Psychopharmacology, 28(2), 185-190. doi:10.1080/24750573.2017.1421398

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. Nature Neuroscience, 14(2), 257-262. doi:10.1038/nn.2726

Salimpoor VN, van den Bosch I, Kovacevic N, McIntosh AR, Dagher A, Zatorre RJ. 2013. Increased functional connectivity of the nucleus accumbens with auditory and valuation regions of the brain predicts reward value of musical excerpts. Science 340:216.

Sandstrom, G. M., & Russo, *F*. A. (2010). Music hath charms: The effects of valence and arousal on recovery following an acute stressor. Music And Medicine, 2(3), 137-143. doi:10.1177/1943862110371486

Sankar, A., Adams, T. M., Costafreda, S. G., Marangell, L. B., & Fu, C. H. Y. (2017). Effects of antidepressant therapy on neural components of verbal working memory in depression. Journal of Psychopharmacology, 31(9), 1176–1183. https://doi.org/10.1177/0269881117724594

Sato, K., Kirino, E., & Tanaka, S. (2015). A voxel-based morphometry study of the brain of university students majoring in music and non- music disciplines, 2015, 1–18.

Satoh, M., Nagata, K., & Tomimoto, H. (2015). Sound Richness of Music Might Be Mediated by Color Perception: A PET Study. Behavioural Neurology, 2015. https://doi.org/10.1155/2015/241804

Satoh, M., Nakase, T., Nagata, K., & Tomimoto, H. (2011). Neurocase Musical anhedonia : Selective loss of emotional experience in listening to music Musical anhedonia : Selective loss of emotional experience in listening to music. Neurocase, 17(5), 410–417. https://doi.org/10.1080/13554794.2010.532139

Schaal, N. K., Krause, V., Lange, K., Banissy, M. J., Williamson, V. J., & Pollok, B. (2015a). Pitch memory in nonmusicians and musicians: Revealing functional differences using transcranial Direct Current stimulation. Cerebral Cortex, 25(9), 2774–2782. https://doi.org/10.1093/cercor/bhu075

Schaal, N. K., Williamson, V. J., & Banissy, M. J. (2013). Anodal transcranial direct current stimulation over the supramarginal gyrus facilitates pitch memory. European Journal of Neuroscience, 38(10), 3513–3518. https://doi.org/10.1111/ejn.12344

Schaal, N. K., Williamson, V. J., Kelly, M., Muggleton, N. G., Pollok, B., Krause, V., & Banissy, M. J. (2015b). A causal involvement of the left supramarginal gyrus during the retention of musical pitches. Cortex, 64, 310–317. https://doi.org/10.1016/j.cortex.2014.11.011

Scheuer, H., Alarcón, G., Demeter, D. V., Earl, E., Fair, D. A., & Nagel, B. J. (2017). Reduced fronto-amygdalar connectivity in adolescence is associated with increased depression symptoms over time. Psychiatry Research - Neuroimaging, 266(October 2016), 35–41. https://doi.org/10.1016/j.pscychresns.2017.05.012

Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of music: Production rules. In P. N. Juslin, J. A. Sloboda, P. N. Juslin, J. A. Sloboda (Eds.), Music and emotion: Theory and research (pp. 361-392). New York, NY, US: Oxford University Press.

Schlaug, G., Marchina, S., & Norton, A. (2008). From singing to speaking: Why singing may lead to recovery of expressive language function in patients with Broca's aphasia. Music Perception, 25(4), 315-323. doi:10.1525/mp.2008.25.4.315

Schnider, A. (2013). Orbitofrontal reality filtering. Frontiers In Behavioral Neuroscience, 7doi:10.3389/fnbeh.2013.00067

Schön, D., Gordon, R., Campagne, A., Magne, C., Astésano, C., Anton, J.-L., & Besson, M. (2010). Similar cerebral networks in language, music and song perception. NeuroImage, 51(1), 450–461. https://doi-org.chain.kent.ac.uk/10.1016/j.neuroimage.2010.02.023

Schubert, E. (2016). Enjoying sad music: Paradox or parallel processes?. Frontiers In Human Neuroscience, 10

Schwartz, R., & Pell, M. D. (2017). When emotion and expression diverge: The social costs of Parkinson's disease. Journal Of Clinical And Experimental Neuropsychology, 39(3), 211-230. doi:10.1080/13803395.2016.1216090

Segarra, N., Metastasio, A., Ziauddeen, H., Spencer, J., Reinders, N. R., Dudas, R. B., … Murray, G. K. (2016). Abnormal frontostriatal activity during unexpected reward receipt in depression and schizophrenia: Relationship to anhedonia. Neuropsychopharmacology, 41(8), 2001–2010. https://doi.org/10.1038/npp.2015.370

Seger, C. A., Spiering, B. J., Sares, A. G., Quraini, S. I., Alpeter, C., David, J., & Thaut, M. H. (2013). Corticostriatal contributions to musical expectancy perception. Journal Of Cognitive Neuroscience, 25(7), 1062-1077. doi:10.1162/jocn_a_00371

Seung, Y., Kyong, J. S., Woo, S. H., Lee, B. T., & Lee, K. M. (2005). Brain activation during music listening in individuals with or without prior music training. Neuroscience Research, 52(4), 323–329. https://doi.org/10.1016/j.neures.2005.04.011

Shahabi, H., & Moghimi, S. (2016). Toward automatic detection of brain responses to emotional music through analysis of EEG effective connectivity. Computers in Human Behavior, 58, 231–239. https://doi.org/10.1016/j.chb.2016.01.005

Shan, Y., Jia, Y., Zhong, S., Li, X., Zhao, H., Chen, J., & ... Wang, Y. (2018). Correlations between working memory impairment and neurometabolites of prefrontal cortex and lenticular nucleus in patients with major depressive disorder. Journal Of Affective Disorders, 227236-242. doi:10.1016/j.jad.2017.10.030

Shen, Y., Yao, J., Jiang, X., Zhang, L., Xu, L., Feng, R., … Chen, W. (2015). Sub-hubs of baseline functional brain networks are related to early improvement following two-week pharmacological therapy for major depressive disorder. Human Brain Mapping, 36(8), 2915–2927. https://doi.org/10.1002/hbm.22817

Shiranibidabadi, S., & Mehryar, A. (2015). Music therapy as an adjunct to standard treatment for obsessive compulsive disorder and co-morbid anxiety and depression: A randomized clinical trial. Journal of Affective Disorders, 184, 13–17. https://doi.org/10.1016/j.jad.2015.04.011

Sieb, R. (2013). The emergence of emotions. Activitas Nervosa Superior, 55(4), 115–145. Retrieved from http://search.ebscohost.com.chain.kent.ac.uk/login.aspx?direct=true&db=psyh&AN=2014-07703-001&site=ehost-live

Silverman, M. J. (2016). Effects of educational music therapy on state hope for recovery in acute care mental health inpatients: A cluster-randomized effectiveness study. Frontiers in Psychology, 7(OCT), 1–10. https://doi.org/10.3389/fpsyg.2016.01569

Sin, W. M., & Chow, K. M. (2015). Effect of music therapy on postoperative pain management in gynecological patients: A literature review. Pain Management Nursing, 16(6), 978-987. doi:10.1016/j.pmn.2015.06.008

Sloboda, J. A., O'Neill, S. A., & Ivaldi, A. (2001). Functions of music in everyday life: An exploratory study using the Experience Sampling Method. Musicae Scientiae, 5(1), 9-32. doi:10.1177/102986490100500102

Smith, R., Lane, R. D., Sanova, A., Alkozei, A., Smith, C., & Killgore, W. D. S. (2018). Common and unique neural systems underlying the working memory maintenance of emotional vs bodily reactions to affective stimuli: The moderating role of trait emotional awareness. Frontiers in Human Neuroscience, 12. https://doi-org.chain.kent.ac.uk/10.3389/fnhum.2018.00370

Soveri, A., Antfolk, J., Karlsson, L., Salo, B., & Laine, M. (2017). Working memory training revisited: A multi-level meta-analysis of n-back training studies. Psychonomic Bulletin & Review, 24(4), 1077–1096. https://doi-org.chain.kent.ac.uk/10.3758/s13423-016-1217-0

Spiro, N., Farrant, C. L., & Pavlicevic, M. (2017). Between practice, policy and politics: Music therapy and the Dementia Strategy, 2009. Dementia: The International Journal Of Social Research And Practice, 16(3), 259-281. doi:10.1177/1471301215585465

Stansfeld, S., Clark, C., Bebbington, P., King, M., Jenkins, R., & Hinchliffe, S. (2016). Chapter 2: Common mental disorders. In S. McManus, P. Bebbington, R. Jenkins, & T. Brugha (Eds.), Mental health and wellbeing in England: Adult Psychiatric Morbidity Survey 2014. Leeds: NHS Digital.

Steinbeis N, Koelsch S, Sloboda J. (2006). The role of harmonic expectancy violations in musical emotions: evidence from subjective physiological and neural responses. J Cogn Neurosci 18(13)80–1393.

Strikwerda-Brown, C., Davey, C. G., Whittle, S., Allen, N. B., Byrne, M. L., Schwartz, O. S., … Harrison, B. J. (2015). Mapping the relationship between subgenual cingulate cortex functional connectivity and depressive symptoms across adolescence. Social Cognitive and Affective Neuroscience, 10(7), 961–968. https://doi.org/10.1093/scan/nsu143

Szczygieł, D., & Maruszewski, T. (2015). Why expressive suppression does not pay? Cognitive costs of negative emotion suppression: The mediating role of subjective tense-arousal. Polish Psychological Bulletin, 46(3), 336–349. https://doi.org/10.1515/ppb-2015-0041

Tabatabaie, A. *F*., Azadehfar, M. R., Mirian, N., Noroozian, M., Yoonessi, A., Saebipour, M. R., & Yoonessi, A. (2014). Neural correlates of boredom in music perception. Basic and Clinical Neuroscience, 5(4), 259–266.

Tabei, K. I. (2015). Inferior frontal gyrus activation underlies the perception of emotions, while precuneus activation underlies the feeling of emotions during music listening. Behavioural Neurology, 2015. https://doi.org/10.1155/2015/529043

Taylor, C. L., & Friedman, R. S. (2014). Differential influence of sadness and disgust on music preference. Psychology of Popular Media Culture, 3(4), 195–205. https://doi.org/http://dx.doi.org/10.1037/ppm0000045

Ter Bogt, T. *F*. M., Vieno, A., Doornwaard, S. M., Pastore, M., & Van Den Eijnden, R. J. J. M. (2017). You're not alone: Music as a source of consolation among adolescents and young adults. Psychology of Music, 45(2), 155–171. https://doi.org/10.1177/0305735616650029

Terao, Y., Mizuno, T., Shindoh, M., Sakurai, Y., Ugawa, Y., Kobayashi, S., … Tsuji, S. (2006). Vocal amusia in a professional tango singer due to a right superior temporal cortex infarction. Neuropsychologia, 44(3), 479–488. https://doi.org/10.1016/j.neuropsychologia.2005.05.013

Thase, M. E., & Schwartz, T. L. (2015). Choosing medications for treatment-resistant depression based on mechanism of action. The Journal Of Clinical Psychiatry, 76(6), 720-727. doi:10.4088/JCP.14052ah2c

Thayer, J. *F*., Åhs, *F*., Fredrikson, M., Sollers, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. Neuroscience and Biobehavioral Reviews, 36(2), 747–756. https://doi.org/10.1016/j.neubiorev.2011.11.009

Tillmann, B., Poulin-Charronnat, B., & Bigand, E. (2014). The role of expectation in music: From the score to emotions and the brain. Wiley Interdisciplinary Reviews: Cognitive Science, 5(1), 105–113. https://doi.org/10.1002/wcs.1262

Trimmer, C., Tyo, R., & Naeem, *F*. (2016). Cognitive behavioural therapy-based music (CBT-Music) group for symptoms of anxiety and depression. Canadian Journal of Community Mental Health, 35(2), 83–87. https://doi.org/10.7870/cjcmh-2016-029

Tracy, D. K., Joyce, D. W., & Shergill, S. S. (2016). Kaleidoscope. The British Journal Of Psychiatry, 209(2), 179-180.

Troeung, L., Gasson, N., & Egan, S. J. (2015). Patterns and predictors of mental health service utilization in people with Parkinson's disease. Journal Of Geriatric Psychiatry And Neurology, 28(1), 12-18. doi:10.1177/0891988714541869

Trost, W., Ethofer, T., Zentner, M., & Vuilleumier, P. (2012). Mapping aesthetic musical emotions in the brain. Cerebral Cortex, 22(12), 2769–2783. https://doi.org/10.1093/cercor/bhr353

Tseng, P., Chen, Y., Lin, P., Tu, K., Wang, H., Cheng, Y., & ... Wu, C. (2016). Significant treatment effect of adjunct music therapy to standard treatment on the positive, negative, and mood symptoms of schizophrenic patients: A meta-analysis. BMC Psychiatry, 16doi:10.1186/s12888-016-0718-8

Turrell, A, S., Halpern, A. & Javadi, A, H. (in preparation). An electroencephalogram exploration of excitement in music.

Van der Does, W. (2002). Different types of experimentally induced sad mood? Behavior Therapy, 33(4), 551–561. https://doi.org/10.1016/S0005-7894(02)80016-8

van Tricht, M. J., Smeding, H. M. M., Speelman, J. D., & Schmand, B. A. (2010). Impaired emotion recognition in music in Parkinson's disease. Brain and Cognition, 74(1), 58–65. https://doi.org/10.1016/j.bandc.2010.06.005

Vik, B. D., Skeie, G. O., Vikane, E., & Specht, K. (2018). Effects of music production on cortical plasticity within cognitive rehabilitation of patients with mild traumatic brain injury. Brain Injury, 32(5), 634-643. doi:10.1080/02699052.2018.1431842

Vines, B. W., Norton, A. C., & Schlaug, G. (2011). Non-invasive brain stimulation enhances the effects of melodic intonation therapy. Frontiers In Psychology, 2doi:10.3389/fpsyg.2011.00230

Vorstenbosch, V., & Laposa, J. M. (2015). Treatment expectancy for anxiety change and response to cognitive behavioral therapy for OCD. Journal Of Obsessive-Compulsive And Related Disorders, 555-60. doi:10.1016/j.jocrd.2015.02.003

Wallmark, *Z*., Deblieck, C., & Iacoboni, M. (2018). Neurophysiological Effects of Trait Empathy in Music Listening. Frontiers in Behavioral Neuroscience, 12(April), 1–19. https://doi.org/10.3389/fnbeh.2018.00066

Wan, C. Y., & Schlaug, G. (2010). Music making as a tool for promoting brain plasticity across the life span. The Neuroscientist, 16(5), 566-577. doi:10.1177/1073858410377805

Wehrum, S., Degé, *F*., Ott, U., Walter, B., Stippekohl, B., Kagerer, S., … Stark, R. (2011). Can you hear a difference? Neuronal correlates of melodic deviance processing in children. Brain Research, 1402, 80–92. https://doi.org/10.1016/j.brainres.2011.05.057

Wasser, C. I., Evans, *F*., Kempnich, C., Glikmann-Johnston, Y., Andrews, S. C., Thyagarajan, D., & Stout, J. C. (2018). Emotion recognition in Parkinson's disease: Static and dynamic factors. Neuropsychology, 32(2), 230-234.

Westbrook, C., Patsenko, E. G., Mumford, J. A., Abramson, L. Y., Davidson, R. J., & Al, W. E. T. (2018). Frontoparietal processing of stress-relevant information differs in individuals with a negative cognitive style, 127(5), 437–447.

Wheeler, B. L., Sokhadze, E., Baruth, J., Behrens, G. A., & Quinn, C. *F*. (2011). Musically induced emotions: Subjective measures of arousal and valence. Music And Medicine, 3(4), 224-233. doi:10.1177/1943862111407513doi:10.1037/neu0000400

Wu, H., Sun, H., Wang, C., Yu, L., Li, Y., Peng, H., … Wang, J. (2017). Abnormalities in the structural covariance of emotion regulation networks in major depressive disorder. Journal of Psychiatric Research, 84, 237–242. https://doi.org/10.1016/j.jpsychires.2016.10.001

Yang, X. hua, Huang, J., Lan, Y., Zhu, C. ying, Liu, X. qun, Wang, Y. fei, … Chan, R. C. K. (2016). Diminished caudate and superior temporal gyrus responses to effort-based decision making in patients with first-episode major depressive disorder. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 64, 52–59. https://doi.org/10.1016/j.pnpbp.2015.07.006

Yang, X. hua, Tian, K., Wang, D. fang, Wang, Y., Cheung, E. *F*. C., Xie, G. rong, & Chan, R. C. K. (2017). Anhedonia correlates with abnormal functional connectivity of the superior temporal gyrus and the caudate nucleus in patients with first-episode drug-naive major depressive disorder. Journal of Affective Disorders, 218(April), 284–290. https://doi.org/10.1016/j.jad.2017.04.053

Yüksel, D., Dietsche, B., Konrad, C., Dannlowski, U., Kircher, T., & Krug, A. (2018). Neural correlates of working memory in first episode and recurrent depression: An fMRI study. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 84(February), 39–49. https://doi.org/10.1016/j.pnpbp.2018.02.003

Zahodne, L. B., & Tremont, G. (2013). Unique effects of apathy and depression signs on cognition and function in amnestic mild cognitive impairment. International Journal of Geriatric Psychiatry, 28(1), 50–56. https://doi.org/10.1002/gps.3789

Zentner, M., Grandjean, D., & Scherer, K. R. (2008). Emotions evoked by the sound of music: Characterization, classification, and measurement. Emotion, 8(4), 494-521. doi:10.1037/1528-3542.8.4.494

Zhao, K., Bai, *Z*. G., Bo, A., & Chi, I. (2016). A systematic review and meta-analysis of music therapy for the older adults with depression. International Journal of Geriatric Psychiatry, 31(11), 1188–1198. https://doi.org/10.1002/gps.4494

Zhu, J., Lin, X., Lin, C., & Zhuo, C. (2017). Distance-dependent alterations in local functional connectivity in drug-naive major depressive disorder. Psychiatry Research - Neuroimaging, 270(June), 80–85. https://doi.org/10.1016/j.pscychresns.2017.10.009

Zhu, J., Lin, X., Lin, C., Zhuo, C., & Yu, Y. (2018a). Selective functional dysconnectivity of the dorsal-anterior subregion of the precuneus in drug-naive major depressive disorder. Journal of Affective Disorders, 225(218), 676–683. https://doi.org/10.1016/j.jad.2017.08.084

Zhu, J., Li, J., Li, X., Rao, J., Hao, Y., Ding, *Z*., … Liu, Q. (2018b). Neural basis of the emotional conflict processing in major depression: ERPs and source localization analysis on the N450 and P300 components. Frontiers in Human Neuroscience, 12(May), 214. https://doi.org/10.3389/FNHUM.2018.00214

Zhu, X., He, Z., Luo, C., Qiu, X., He, S., Peng, A., … Chen, L. (2018c). Altered spontaneous brain activity in MRI-negative refractory temporal lobe epilepsy patients with major depressive disorder: A resting-state fMRI study. Journal of the Neurological Sciences, 386(37), 29–35. https://doi.org/10.1016/j.jns.2018.01.010

Zimmermann, K. S., Li, C., Rainnie, D. G., Ressler, K. J., & Gourley, S. L. (2018). Memory retention involves the ventrolateral orbitofrontal cortex: Comparison with the basolateral amygdala. Neuropsychopharmacology, 43(2), 373-383. doi:10.1038/npp.2017.139

# 7 Supplementary Materials

*Table 9.* Displays the main themes, sub-themes and count for activities engaged in when participants completed daily music tasks

| **Main Themes** | **Main Theme Count** | | | **Sub Themes** | **Sub Theme Count** | | |
|---|---|---|---|---|---|---|---|
| | **E** | **C** | **T** | | **E** | **C** | **T** |
| Relaxing/Resting | 43 | 29 | 72 | Sitting | 15 | 3 | 18 |
| | | | | Relaxing | 6 | 7 | 13 |
| | | | | Laying in bed | 4 | 15 | 19 |
| | | | | Doing Nothing | 18 | 2 | 20 |
| | | | | Looking out Window | 0 | 1 | 1 |
| | | | | Meditating | 0 | 1 | 1 |
| Reading | 16 | 2 | 18 | | 16 | 2 | 18 |
| Studying/Working | 9 | 11 | 20 | Studying | 5 | 10 | 15 |
| | | | | Library | 1 | 0 | 1 |
| | | | | Writing/Responding emails | 3 | 0 | 3 |
| | | | | Work | 0 | 1 | 1 |
| Internet/Device/App Surfing | 13 | 18 | 31 | Social Media | 6 | 13 | 19 |
| | | | | Surfing internet | 4 | 2 | 6 |
| | | | | Surfing Phone | 2 | 0 | 2 |
| | | | | Online shopping | 1 | 0 | 1 |
| | | | | Texting | 0 | 3 | 3 |
| Entertainment | 11 | 13 | 24 | Playing games | 4 | 2 | 6 |
| | | | | Watching TV | 5 | 6 | 11 |
| | | | | Crochet | 2 | 0 | 2 |
| | | | | Juggling | 0 | 3 | 3 |
| | | | | Podcast | 0 | 1 | 1 |
| | | | | Watching Film | 0 | 1 | 1 |
| Cleaning/Tidying | 6 | 7 | 13 | | 6 | 7 | 13 |
| Outside Activities | 2 | 4 | 6 | Taxi | 1 | 0 | 1 |
| | | | | Boarding Plane | 1 | 0 | 1 |
| | | | | Packing/unpacking | 0 | 2 | 2 |
| | | | | Planning trip | 0 | 1 | 1 |
| | | | | Walking | 0 | 1 | 1 |
| Getting Ready | 8 | 13 | 21 | For bed | 3 | 0 | 3 |
| | | | | Make-up | 2 | 10 | 12 |
| | | | | Painting Nails | 1 | 1 | 2 |
| | | | | to Go Out | 2 | 1 | 3 |
| | | | | Shaving | 0 | 1 | 1 |
| Food & Drink | 10 | 9 | 19 | Eating | 4 | 3 | 7 |
| | | | | Cooking | 5 | 5 | 10 |
| | | | | Making/Drinking Coffee | 1 | 1 | 2 |

*Note*. E = Experimental, C = Control, T = Total counts for each activity occurring across the intervention.

*Table 10.* Results from the 2 × 3 (condition by intervention session) mixed-model ANOVA on Drop clips excitement ratings

| **Effect** | **DF** | ***F*** | **P** | **ηp2** |
|---|---|---|---|---|
| Excitement Rating Session Main Effect | 2,30 | 2.68 | .085* | .15††† |
| Condition Main Effect | 1,15 | .31 | .58 | .02† |
| Excitement Rating Session × Condition Interaction | 2,30 | .59 | .56 | .04† |

*Note.* DF: degrees of freedom; *F*: *F*-values; *p*: significance * $p < .10$, ** $p < .05$, *** $p < .01$; ηp2: partial eta squared effect size † = small effect size, †† = medium effect size, ††† = large effect size.

*Table 11.* Custom table showing participant daily average scores for positive PANAS items

| Condition | Participant | Day/Session | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| Control | 1 | 12 | 11 | 13 | 13 | 13 | 12 | 14 | 14 | 14 | 15 | . | . |
| | 2 | 14 | 13 | 14 | 13 | 11 | 13 | 13 | 13 | 15 | 16 | 16 | 17 |
| | 3 | 1 | 8 | 1 | 9 | 9 | 6 | 8 | 9 | 9 | . | . | . |
| | 4 | 1 | 1 | 11 | 1 | 13 | 18 | 13 | 18 | 12 | 19 | . | . |
| | 5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | 6 | 15 | 15 | 15 | 12 | 15 | 14 | 15 | 17 | 18 | 17 | 17 | 16 |
| | 7 | 18 | 15 | 16 | 17 | 14 | 17 | 17 | 17 | 16 | 16 | 15 | 15 |
| | **Mean** | 9 | 9.29 | 10.29 | 9.57 | 11 | 11.71 | 11.71 | 12.86 | 12.29 | 14.17 | 12.5 | 12.5 |
| | **Median** | 12 | 11 | 13 | 12 | 13 | 13 | 13 | 14 | 14 | 16 | 15.5 | 15.5 |
| Experimental | 1 | 1 | 1 | 11 | 11 | 11 | 12 | 12 | 1 | 1 | 11 | 12 | . |
| | 2 | 17 | 16 | 15 | 15 | 16 | 15 | 17 | 18 | 18 | 18 | 18 | 18 |
| | 3 | 1 | 1 | 12 | 12 | 12 | 1 | 12 | 1 | 1 | 12 | 1 | . |
| | 4 | 14 | 15 | 14 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 13 |
| | 5 | 16 | 18 | 17 | 17 | 13 | 16 | 16 | 14 | 15 | 14 | 14 | . |
| | 6 | 14 | 14 | 15 | 15 | 15 | 15 | 14 | 14 | 11 | 13 | 14 | 13 |
| | 7 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 17 | 16 | 17 | . | . |
| | 8 | 12 | 12 | 1 | 12 | 12 | 12 | 11 | 12 | 11 | 12 | 12 | . |
| | 9 | 16 | 13 | 12 | 13 | 12 | 12 | 12 | 12 | 12 | . | . | . |
| | 10 | 17 | 18 | 18 | 16 | 18 | 18 | 18 | 18 | 18 | 18 | . | . |
| | **Mean** | 12.6 | 12.6 | 13.3 | 14.4 | 14.2 | 13.4 | 14.5 | 12.2 | 11.8 | 14.44 | 12.29 | 14.67 |
| | **Median** | 15 | 14.5 | 14.5 | 15 | 14 | 15 | 14.5 | 14 | 13.5 | 14 | 14 | 13 |

*Note.* Mean: refers to means of all participants scores in each condition across each day; Median: refers to medians of all participants scores in each condition across each day.

*Table 12.* Custom table showing participant daily average scores for negative PANAS items

| Condition | Participant | Day/Session | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| Control | 1 | 18 | 18 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | . | . |
| | 2 | 12 | 12 | 12 | 11 | 12 | 9 | 9 | 11 | 9 | 12 | 14 | 11 |
| | 3 | 14 | 15 | 15 | 14 | 13 | 14 | 14 | 14 | 12 | . | . | . |
| | 4 | 13 | 13 | 1 | 12 | 12 | 1 | 9 | 9 | 9 | 8 | . | . |
| | 5 | 11 | 1 | 1 | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 6 | 13 | 13 | 14 | 16 | 13 | 15 | 15 | 14 | 14 | 15 | 14 | 16 |
| | 7 | 11 | 1 | 1 | 12 | 11 | 11 | 14 | 11 | 11 | 11 | 1 | 11 |
| | **Mean** | 13.14 | 10.43 | 6.57 | 11.29 | 9.14 | 7.57 | 9.14 | 8.86 | 8.29 | 8.17 | 7.5 | 9.75 |
| | **Median** | 13 | 13 | 2 | 12 | 12 | 9 | 9 | 11 | 9 | 9.5 | 7.5 | 11 |
| Experimental | 1 | 12 | 12 | 12 | 12 | 1 | 1 | 11 | 8 | 1 | 8 | 9 | . |
| | 2 | 11 | 11 | 11 | 11 | 13 | 9 | 9 | 1 | 8 | 8 | 9 | 8 |
| | 3 | 15 | 15 | 14 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | . |
| | 4 | 15 | 13 | 13 | 1 | 11 | 11 | 1 | 1 | 1 | 1 | 1 | 11 |
| | 5 | 1 | 12 | 11 | 1 | 11 | 11 | 1 | 1 | 1 | 1 | 1 | . |
| | 6 | 8 | 9 | 9 | 8 | 8 | 8 | 7 | 8 | 7 | 8 | 8 | 8 |
| | 7 | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 17 | 15 | . | . |
| | 8 | 1 | 9 | 11 | 9 | 9 | 1 | 9 | 9 | 9 | 1 | 1 | . |
| | 9 | 14 | 15 | 13 | 12 | 13 | 12 | 12 | 12 | 12 | . | . | . |
| | 10 | 9 | 9 | 8 | 12 | 12 | 11 | 9 | 9 | 9 | 7 | . | . |
| | **Mean** | 10.2 | 12 | 11.7 | 9.6 | 10.8 | 9.4 | 8.9 | 7.8 | 7.9 | 7 | 6.14 | 9 |
| | **Median** | 11.5 | 12 | 11.5 | 11.5 | 11.5 | 11 | 9 | 8.5 | 8.5 | 8 | 8 | 8 |

*Note*. Mean: refers to means of all participants scores in each condition across each day; Median: refers to medians of all participants scores in each condition across each day.

*Table 13.* Results from the 2 × 2 × 2 (condition by intervention day by emotion) PANAS scores ANOVA

| **Effect** | **DF** | ***F*** | **P** | **ηp2** |
|---|---|---|---|---|
| Intervention Day Main Effect | 1,15 | .18 | .68 | .012 † |
| Emotion Main Effect | 1,15 | 1.11 | .31 | .069 † † |
| Condition Main Effect | 1,15 | .001 | .97 | .000 |
| Intervention Day by Condition Interaction | 1,15 | .11 | .75 | .007 |
| Emotion by Condition Interaction | 1,15 | .86 | .37 | .054 † |
| Intervention Day by Emotion Interaction | 1,15 | 9.00 | .009*** | .36 † † † |
| Intervention day by Emotion by Condition Interaction | 1,15 | 3.54 | .080* | .19 † † † |

*Note.* DF: degrees of freedom; *F*: *F*-values; *p*: significance * $p < .10$, ** $p < .05$, *** $p < .01$; ηp2: partial eta squared effect size † = small effect size, †† = medium effect size, ††† = large effect size.

*Table 14.* Results from post-hoc t-tests comparing Pre-, Post- and Follow-up sessions in the Experimental condition

| **Comparison** | **DF** | ***t*** | **Two-tailed P** | **Difference M** |
|---|---|---|---|---|
| Pre to Post | 8 | 2.67 | .03 | 8.22 |
| Post to Follow-up | 8 | 1.51 | .17 | 1.78 |
| Pre to Follow-up | 8 | 2.87 | .02 | 10.00 |

*Note.* DF: degrees of freedom; *t*: t-values; two-tailed *p*: significance * $p < .10$, ** $p < .05$, *** $p < .01$; Difference M; difference between mean scores.

*Table 15.* Results from post-hoc t-tests comparing Pre-, Post- and Follow-up sessions in the Control condition

| **Comparison** | **DF** | ***t*** | **Two-tailed P** | **Difference M** |
|---|---|---|---|---|
| Pre to Post | 7 | 1.33 | .26 | 4.25 |
| Post to Follow-up | 7 | -1.00 | .35 | -1.25 |
| Pre to Follow-up | 7 | 1.01 | .35 | 3.00 |

*Note.* DF: degrees of freedom; *t*: t-values; two-tailed *p*: significance * $p < .10$, ** $p < .05$, *** $p < .01$; Difference M; difference between mean scores.

*Table 16*. Custom table showing mean participant scores in WM counting span task across Pre-, Post- and Follow-up sessions and overall means, medians, and standard errors

| **Condition** | **Participant** | **Session** | | |
|---|---|---|---|---|
| | | **1** | **2** | **3** |
| Control | 1 | 9 | 6 | 10 |
| | 2 | 8 | 7 | 9 |
| | 3 | 7 | 6 | 4 |
| | 4 | 5 | 8 | 10 |
| | 5 | 7 | 9 | 6 |
| | 6 | 10 | 7 | 9 |
| | 7 | 9 | 10 | 10 |
| | 8 | 7 | 8 | 5 |
| | 9 | 10 | 10 | 7 |
| | **Mean** | 8 | 7.89 | 7.78 |
| | **Median** | 8 | 8 | 9 |
| | **SEM** | 0.52 | 0.48 | 0.73 |
| Experimental | 1 | 7 | 7 | 6 |
| | 2 | 7 | 8 | 9 |
| | 3 | 9 | 10 | 9 |
| | 4 | 1 | 7 | 6 |
| | 5 | 7 | 7 | 7 |
| | 6 | 8 | 8 | 8 |
| | 7 | 6 | 6 | 6 |
| | 8 | 7 | 8 | 7 |
| | 9 | 7 | 9 | 7 |
| | 10 | 7 | 7 | 9 |
| | **Mean** | 6.6 | 7.7 | 7.4 |
| | **Median** | 7 | 7.5 | 7 |
| | **SEM** | 0.64 | 0.35 | 0.38 |

*Note.* SEM = standard error of measurement.

*Table 17.* Means and standard errors across Pre-, Post-, and Follow-up WM scores for both conditions

| **Intervention Session** | **M(SEM)** |
|---|---|
| Pre- intervention | 7.30(.44) |
| Post-intervention | 7.79(.31) |
| Follow-up intervention | 7.59(.42) |

*Note.* M = Mean; SEM = standard error of measurement.

*Table 18.* Means and standard errors of WM scores across Experimental and Control conditions

| **Condition** | **M(SEM)** |
|---|---|
| Experimental | 7.23(.39) |
| Control | 7.89(.42) |

*Note.* M = Mean; SEM = standard error of measurement.

*Table 19.* Output for the 2 × 3 (condition by session) ANOVA on WM scores

| **Analysis** | **DF** | ***F*** | ***p*** | **ηp2** |
|---|---|---|---|---|
| Session Main Effect | 2,34 | .55 | .58 | .03† |
| Condition Main Effect | 1,17 | 1.31 | .27 | .07†† |
| Session by Condition Interaction | 2,34 | .95 | .39 | .05† |

*Note.* DF: degrees of freedom; *F*: *F*-values; *p*: significance; ηp2: partial eta squared effect size † = small effect size, †† = medium effect size, ††† = large effect size.

*Table 20.* Custom table showing the trend of participant responses to the question "How familiar did you find the music you listened to today?"

| **Condition** | **Participant** | **Day/Session** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| Control | 1 | 1 | 3 | - | 3 | 3 | 3 | - | 3 | 2 | 3 | 3 | 3 |
| | 2 | 4 | 2 | 3 | 3 | 3 | 4 | 3 | 2 | 3 | 1 | 3 | 2 |
| | 3 | 3 | - | 2 | 2 | 2 | - | 2 | - | 2 | 3 | 3 | 2 |
| | 4 | 2 | 1 | 3 | 1 | - | 2 | 1 | 1 | 3 | 4 | - | 3 |
| | 5 | 1 | 1 | - | 1 | 2 | - | - | 1 | 1 | 2 | 1 | 1 |
| | 6 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 3 |
| | 7 | 3 | 2 | 1 | 2 | 1 | 1 | 4 | 3 | 3 | 2 | 1 | 3 |
| | 8 | 2 | 4 | 3 | 3 | 2 | 2 | - | 3 | 3 | 3 | 4 | 4 |
| Experimental | 1 | 3 | 1 | 3 | - | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 2 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| | 4 | 3 | 1 | 2 | 4 | - | 3 | 1 | 2 | 2 | 2 | 3 | 4 |
| | 5 | 1 | 1 | 4 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 3 | 1 |
| | 6 | 4 | 1 | 3 | 3 | - | 3 | 2 | 2 | - | 2 | 2 | 3 |
| | 7 | 2 | 2 | 2 | 2 | - | 2 | 1 | 2 | 3 | 2 | 2 | 2 |
| | 8 | 3 | - | 2 | 2 | - | 1 | 1 | 3 | 1 | 4 | - | 1 |
| | 9 | - | 3 | 2 | - | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 1 |

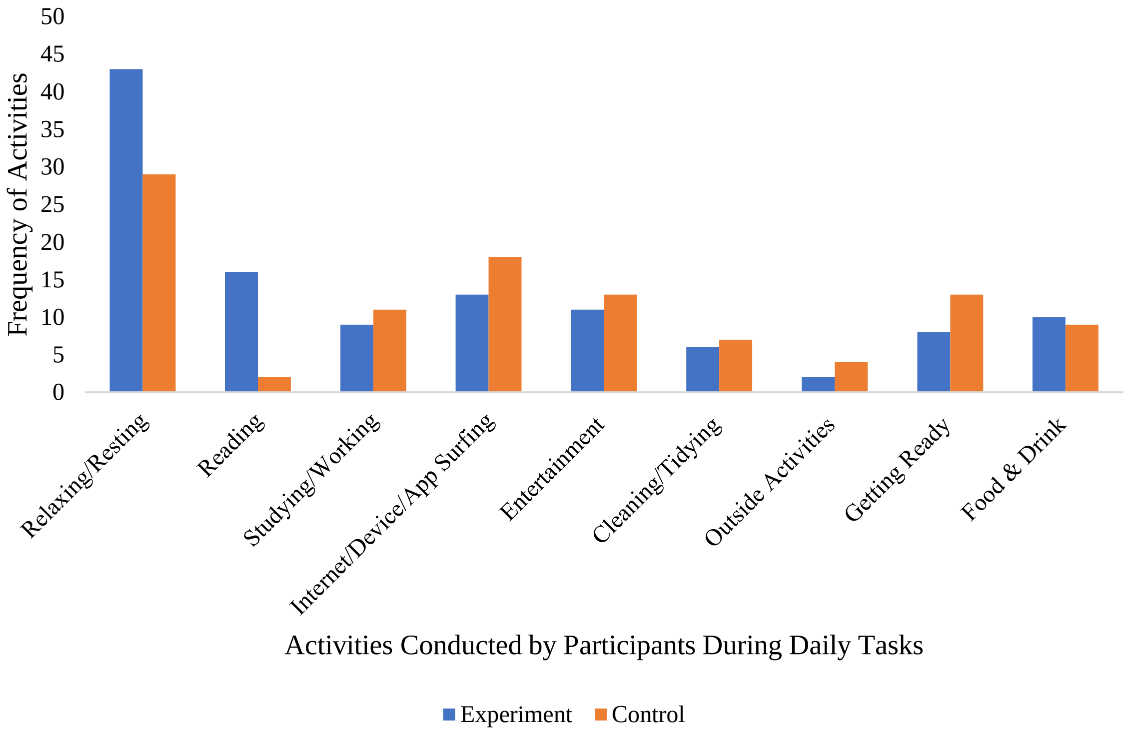



*Figure 13*. The count for types of activities engaged in by participants during the daily music tasks across conditions.

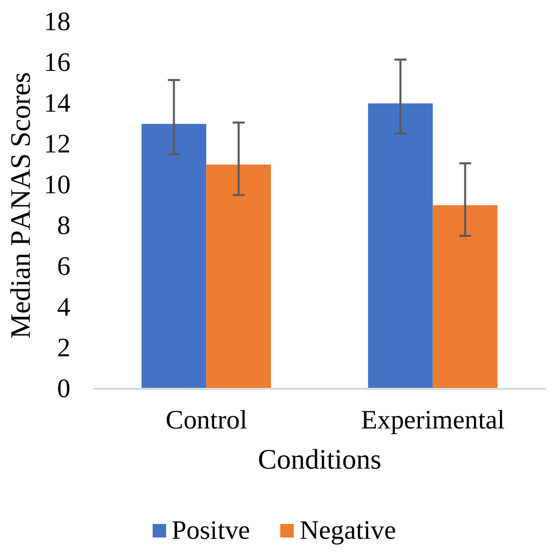



*Figure 14*. A graph of median positive and negative PANAS scores across Control and Experimental conditions.

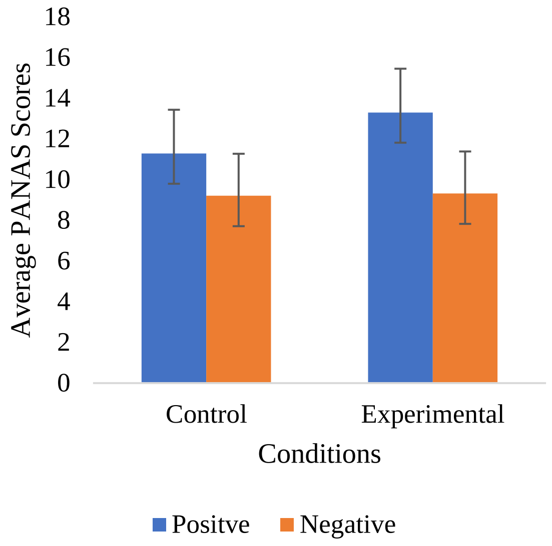



*Figure 15*. A graph of average positive and negative PANAS scores across Control and Experimental conditions.

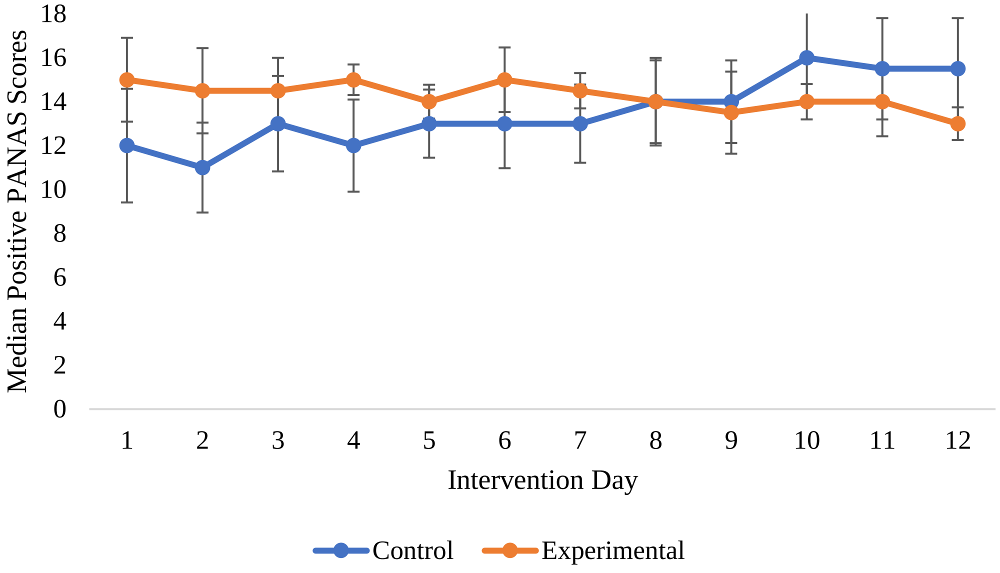



*Figure 16.* A graph of median changes in positive PANAS scores across the 12 day intervention.

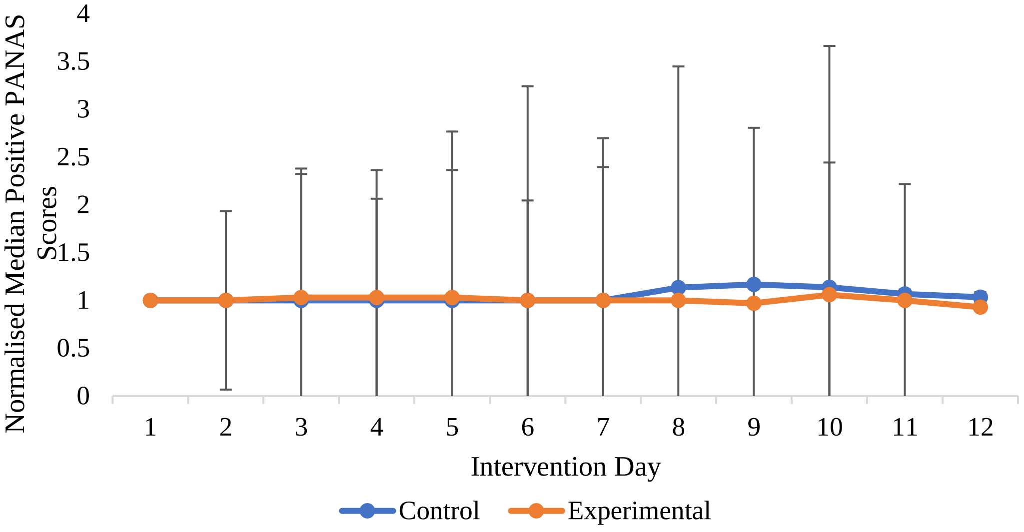



*Figure 17.* A graph of median changes in normalised positive PANAS scores across the 12 day intervention.

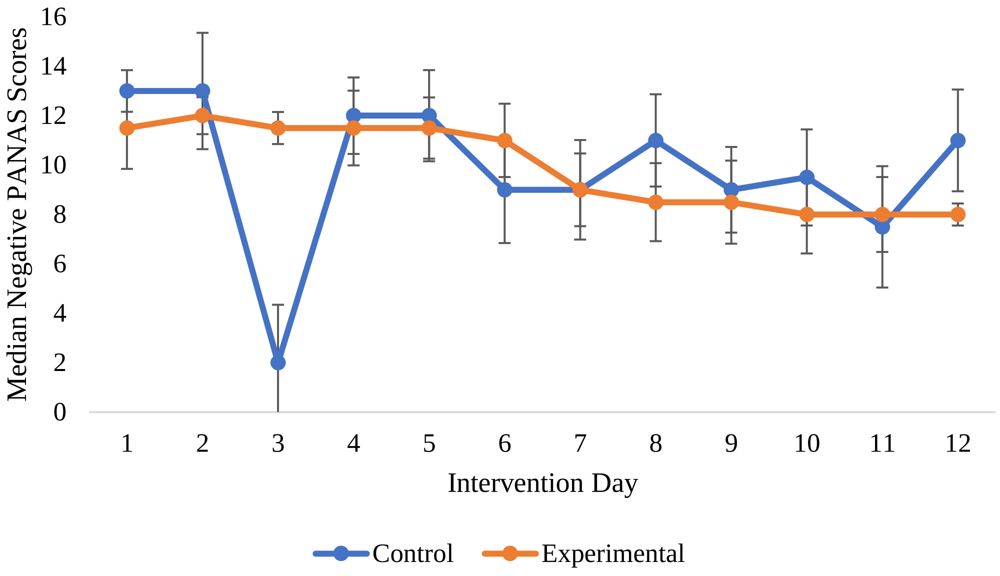



*Figure 18.* A graph of median changes in negative PANAS scores across the 12 day intervention.

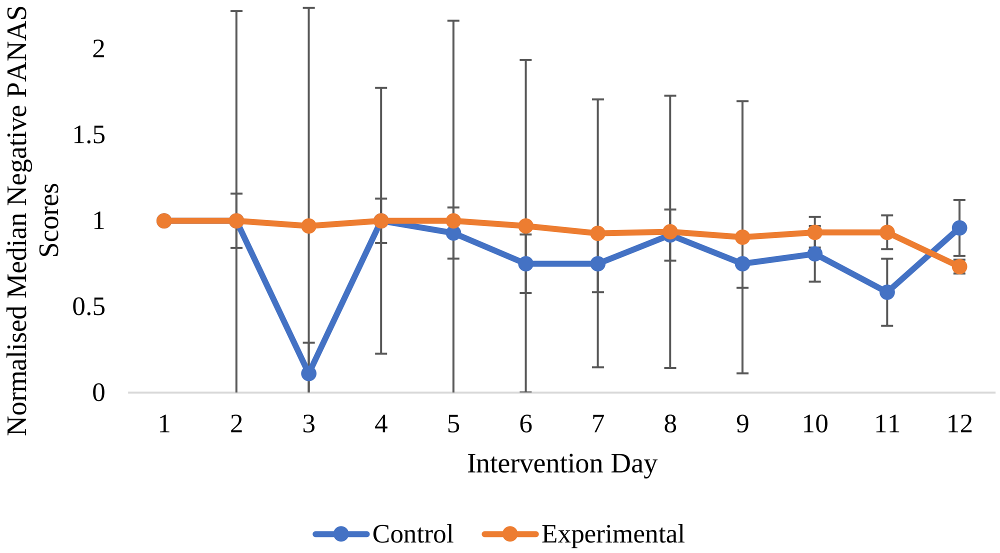



*Figure 19*. A graph of median changes in normalised negative PANAS scores across the 12 day intervention.

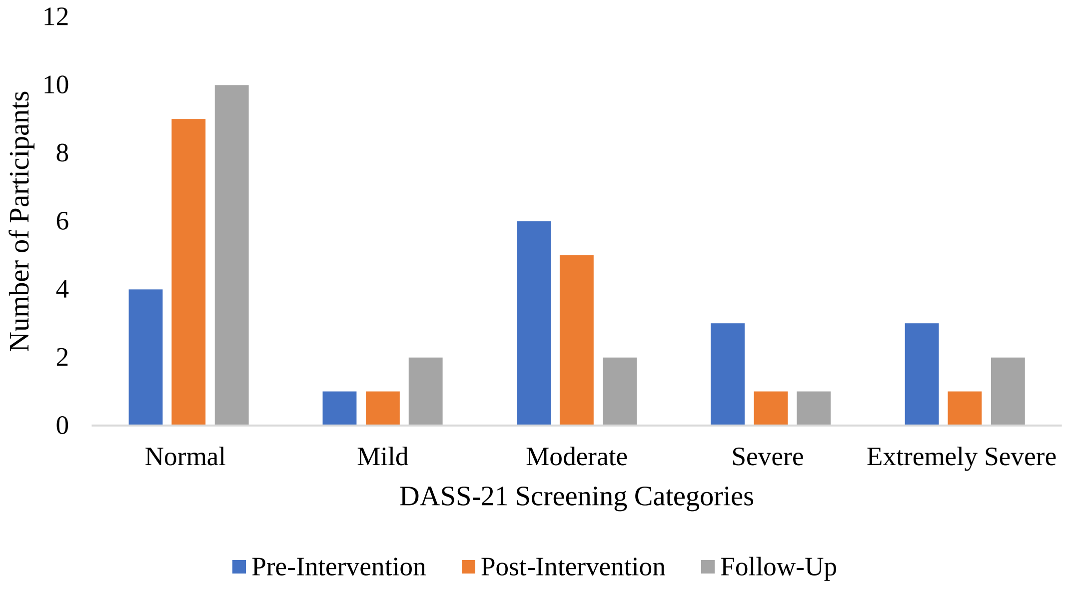



*Figure 20.* The count of participants in each DASS-21 screening depression category (Normal, Mild, Moderate, Severe, and Extremely Severe) across Pre-, Post- and Follow-up intervention sessions.

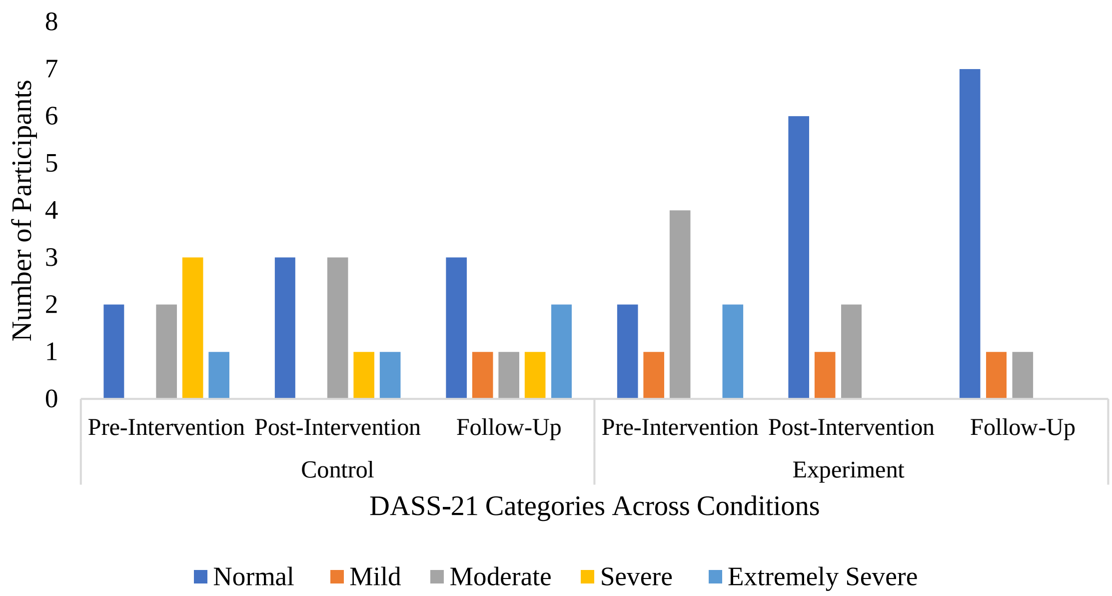



*Figure 21.* The count of participants in each DASS-21 screening depression category (Normal, Mild, Moderate, Severe, and Extremely Severe) across Pre-, Post- and Follow-up intervention sessions, as well as between Control and Experimental conditions.

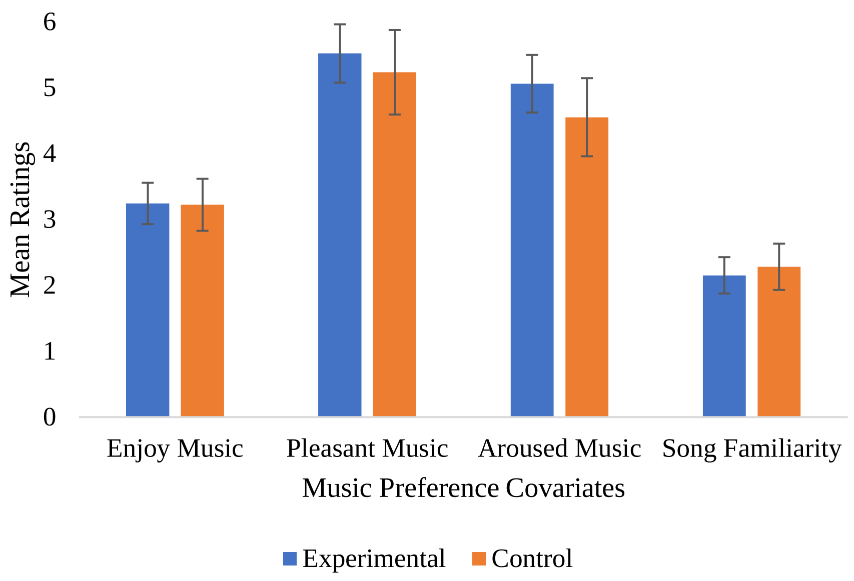



*Figure 22.* Mean differences in enjoyment, pleasantness, arousal, and song familiarity during daily apprehended music across Experimental and Control conditions

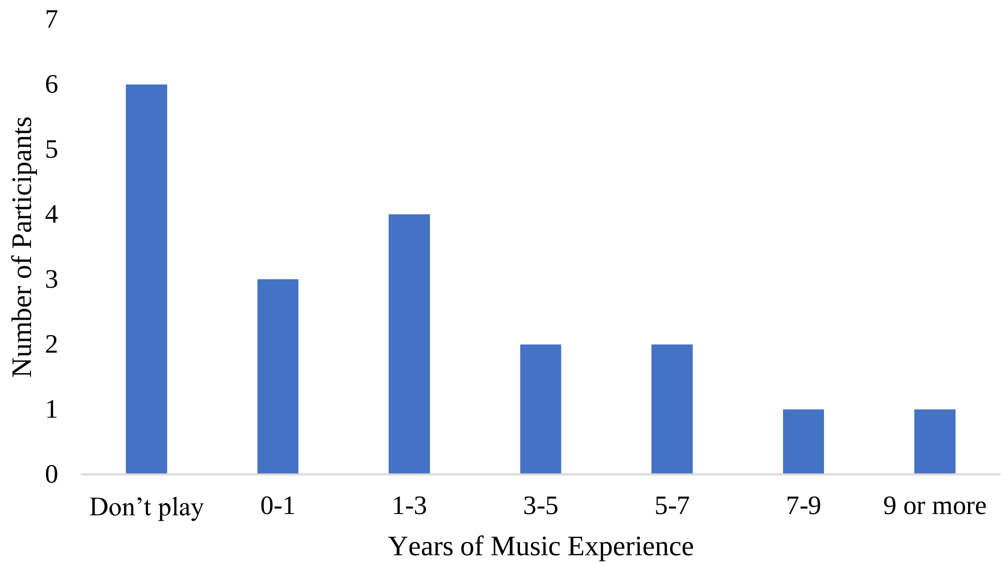



*Figure 23*. Figure 14. The number of participants in each category of musical experience in years.

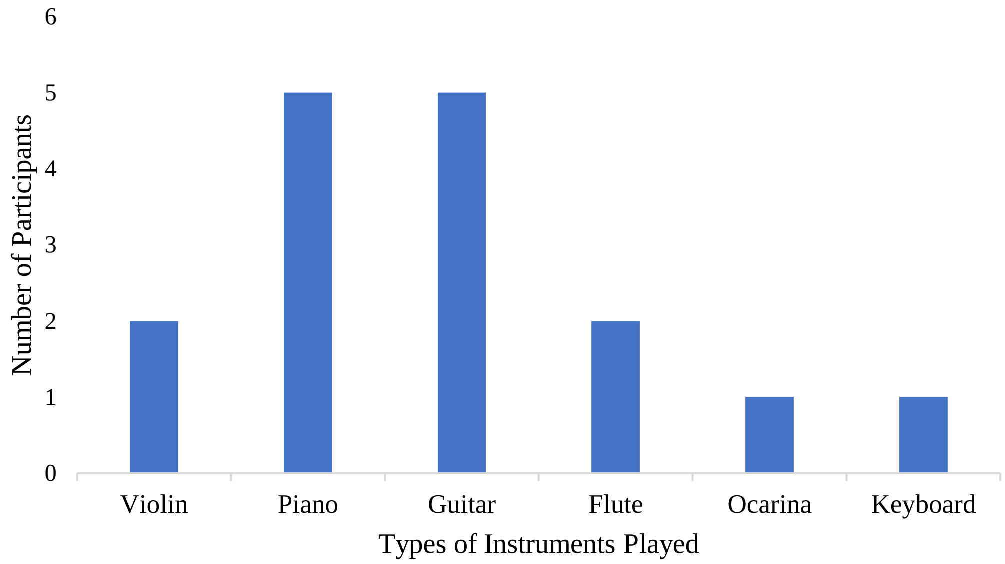



*Figure 24*. A graph showing the types and frequencies of musical instruments played by participants.

# 8 Glossary

## A

*Absolute pitch (AP):* another phrase for 'perfect pitch', meaning the ability to detect pitch in relation to a fixed level in the frequency of sound vibrations

*Aesthetics:* is a **music emotion** and refers to the notion of appreciation and pleasurable experiences through beauty

*Alexithymia:* is the **mental health disorder** related to the incapability to describe and identify emotions in the self. Main symptoms include impaired emotional awareness, social attachment and interpersonal relations

*Alpha frequency power:* refers to 'frequency power', which is the strength or amplitude of 'oscillatory' activity in different frequencies. Within Alpha, frequency power varies between 8-12 Hz.

*Alzheimer's:* is the most common type of 'Dementia', a progressive condition often in the elderly impeding numerous brain functions. Symptoms include; confusion, disorientation, inability to make decisions, difficulties with language, reduction in self-care, personality alterations, reduced social functioning, hallucinations or delusions, and low mood or anxiety

*Amusia:* also termed 'tone deafness' and means "a lack of music". It is the incapability to recognise and reproduce musical tones

*Anger management:* a psychological therapy designed and implemented to help manage anger, including; one-to-one and group counselling, and 'cognitive behavioural therapy (CBT)' *See 'C' section*

*Angular gyrus:* is also referred to as Brodmann area 39 and is located in the parietal lobe. Its main functions include language, attention and music processing

*Anhedonia:* is a **mental health** problem in which the sense of pleasure in rewarding experiences is lost

*Anodal brain stimulation:* is when **brain stimulation** is used to increase neuronal activity; the stimulation enables depolarization allowing for greater neuronal excitability and impulsive firing

*Antidepressants:* are an **intervention** consisting of prescribed medication, usually tablets, utilised to treat depression symptoms

*Anxiety:* a **mental health disorder**, the most common anxiety disorder is generalised anxiety disorder (GAD) which is a long-term disorder resulting in feelings of anxiety (experiences of fear, unease and worry) within numerous situations. Symptoms include; restlessness, concentration problems, sleep difficulties, heart palpitations and irregular sensations in body limbs

*Aphasia:* is the inability to produce and comprehend language in speech, writing and reading. It results from brain damage, usually occurring after stroke.

*Apps:* stands for the word 'Application' and refers to software often downloaded on mobile devices

*Arousal:* is when sense organs, including eye, ears, mouth, etc are stimulated to enable perception; it is an awake physiological and psychological state allowing attention, and is the counterpart to 'Valence' when exploring emotion

*Auditory processes:* are the innate processes of ears detecting sounds and information travelling to the brain for interpretation. 'Auditory processing disorder' occurs when there are deficits in processing audited information, despite normal hearing

*Autism:* is a developmental life-long disability, influencing how people observe the world and impedes social interactions

**B**

*Bilateral brain activity:* indicates to activity occurring in both sides (hemispheres) of the brain

*Bipolar:* a **mental health disorder** consisting of extreme depressive and/or manic episodes

*Blood volume:* is the **physiological response** of amount of blood within an individual's circulatory system, the average is 5 litres and the amount is controlled by the Kidneys

*Brain lesion:* also called 'lesions on the brain' and broadly refers to all forms of irregular tissue in or on the brain. Different types include; malignant, immune, plaques, traumatic, vascular, genetic, benign, and infectious

*Brain stimulation:* is the process of inducing brain activity via different mechanisms including; magnetic stimulation creating a magnetic pulse and electrical stimulation sending small electrical currents to the brain, these can be invasive or non-invasive

**C**

*Cathodal brain stimulation:* is a negative type of **brain stimulation** which reduces neuronal activity; the stimulation evokes hyperpolarization, resulting in decreased neuronal excitability and impulsive firing

*'chills':* are one example of '**music-emotions**' where music listeners experience strong positive emotional responses as well as significant physiological reactions that are described to feel like 'chills'

*Chronic migraine:* refers to fifteen or more headaches a month that are painful and incapacitating in daily tasks

*Classical:* is perhaps the oldest **music genre**, dating back to the 18$^{th}$ century and uses traditional instruments such as piano, violin, flute etc to follow long established musical principles in the creation of concertos, symphonies and sonatas

*Cognitive Behavioural Therapy (CBT):* a form of psychological talking therapy, targeting the way you think and behave in the current moment. Basic concept that thoughts, emotions, physiology and behaviour are all connected and negative thinking enables a re-occurring cycle of negativity. Therapy provides guidance to positive thinking and managing behaviour

*Cognition/cognitive functions:* the mental process or action of gaining knowledge and understanding through senses, experiences, and thoughts

*Co-morbid disorders:* are disorders co-occurring with other disorders and one primary disease or disorder (e.g. stroke is a primary disease with depression and aphasia as co-morbid disorders)

*Cortical thickness:* is a brain measurement applied to detail the overall thickness of the cerebral cortex in specific areas or in the entire brain

**D**

*Dance therapy:* is the use of dance in accredited clinical and evidence-based research and **interventions**.

*DASS-21:* refers to the shorter 21 question version of the 'depression, anxiety and stress scale' used to screen for normal, mild, moderate, severe, and extremely severe depression, anxiety and stress

*Depression:* is a common **mental health disorder** that negatively impacts actions, thoughts and feelings. Symptoms include; fatigue and loss of interest in activities, sad and guilty feelings, changes in appetite, sleep difficulties, concentration problems, and suicidal thoughts

*Drop:* is a highly deviating section of music, particularly in dance music, where musical features such as rhythm, tempo, beat, bass, frequency, amplitude etc increasingly build to then stop or slow and significantly alter

*Direct electrical brain stimulation (dEBS):* also referred to as focal simulation and is type of **brain stimulation** using direct electrical currents to specific neurons or neuronal networks

*Disorders of consciousness:* is the occurrence of impaired consciousness (consisting of wakefulness and awareness) due to brain damage and includes minimally conscious states, vegetative states and comas

*Dementia:* is an umbrella term used to define numerous disorders of progressive cognitive and neurological decline. There a several types, the most common being Alzheimer's, but others include frontotemporal, vascular and with Lewy bodies

**E**

*EEG:* refers to the **neuroimaging technique** of using electrodes on the scalp to record neuronal alterations in the brain, as it detects small electrical charges emitted by neurons as they fire (the basis of all brain processes)

*Electronic:* also referred to as 'Electronica' and is an umbrella **music genre** for any music using electronic, digital or circuity-based instruments to create sound, including; electronic dance music, house, techno, industrial dance, and trance music

*Emotional bias:* is a distortion in emotional processing to assess things more in line with one emotion and can lead to skewed decision making and cognition

*Emotional regulation / control:* is the capability to respond to continuous demands and experiences in life with an array of flexible and sociably acceptable emotions allowing the experience of spontaneous responses and the ability to delay impulsive reactions when required

*Empathy:* a **music-emotion** referring to the capacity to acknowledge, apprehend, and share emotions with others

*Episodic memory:* a **cognitive function** and the explicit recall of autobiographical events, including context, emotions, time, and place. Also referred to as memory of past experiences from a specific place and time

*Executive functioning:* part **cognitive functioning** and is an umbrella term for numerous behaviours such as self-regulation, organisation, planning and mental control, enabling self-management and goal achievement

*Explicit:* can refer to memory and emotions and means remembering an experience or experiencing an emotion purposefully and consciously

**F**

*Frontal asymmetry:* is a subcategory of 'brain asymmetry' specifically within the frontal cortex and means none-similar brain activity between left and right frontal brain areas.

*Frontotemporal lobar degeneration (FTLD):* is the progressive pathological decline that occurs in frontotemporal dementia, specifically the weakening of frontal and temporal lobes in the brain

*Functional magnetic resonance imaging (fMRI):* a **neuroimaging technique** that detects changes within the brain by forming detailed images via alterations in cerebral blood flow. It assumes increased blood flow to a brain region insinuates greater neuronal activity in that area

**G**

*General functioning:* is applied to assess cognitive impairment, usually post brain damage, and assesses the capability of patients in everyday living tasks

*Grey matter:* is one kind of tissue within the brain and consists of cell bodies, dendrites, axon terminals and synapses

**H**

*Heart rate/ HR variability:* Heart rate refers to the **physiological response** of average number of heart beats per minute. Heart rate variability assesses the variations in time between sequential heart beats

*Hemispatial neglect:* also referred to as hemineglect, spatial neglect or unilateral neglect; is a common disorder occurring post brain damage and results in the inability to attend to one side of space

*Hip-hop:* is a specific form of 'rap' **music genre**, again created in the 1970's by urban African-Americans, and includes a rhythmic beat overlapped by rapped vocals

**I**

*Inferior frontal gyrus:* is in the top part of the frontal lobe and consists of Brodmann areas 44, 45, and 47. Its main functions are in language and music processing

*Inferior temporal gyrus:* is within the bottom of the temporal lobe and is referred to as Brodmann area 20. Its main functions include processing language, visual information, memory, and music

*Intervention:* when used in a medical sense, refers to planned actions utilised to improve a medical disorder

*Implicit:* can also relate to memory and emotions and is the unconscious and involuntary recollection of experiences and elicitation of emotions

**J**

**K**

*Key:* is a **music feature** referring to the group of musical pitches or chords that create the music's basis and can be present in either major or minor mode

**L**

*Lyrics:* are the **music features** of words sung alongside music

**M**

*Melody:* a **music feature** that originates from Greek and means to sing or chant. It refers to the perception of a linear pattern of musical notes as a single harmonic unit, forming a musically sufficient tune

*Memory:* is a **cognitive function** which broadly encodes, stores and retrieves information. There are numerous types including, episodic, long-term, short-term and working memory

*Mental Health disorders (MH):* are medical illness's involving alterations in combinations of behaviours, thoughts and emotions which result in distress and impaired work, social, and family functioning

*Metal:* also called 'heavy metal' is a **music genre** formed in the 1960/70's within the UK and consists of heavy drums and electronic guitar use in fast changing rhythms

*Mild TBI:* accounts for 75-80% of all **traumatic brain injuries** and are categorised by a short period of unconsciousness or feelings of dizziness and sickness after some trauma to the head

*Musical Anhedonia:* refers to the inability to enjoy listening to music and experiencing music-emotions despite normal apprehension of music features

*Music deviations:* are sudden unexpected changes in music that move away from the usual previous structure of musical features

*Music-emotions:* refers to a cluster of complex emotions that are experienced uniquely in music

*Music expectancy:* is the created assumptions of music's future structure due to the previous format of musical features such as tempo, rhythm and frequency

*Music features:* are the components of musical sound such as keys, tempo, bass and rhythm that together form music in formal structures such as songs

*Music genre:* refers to the classification of music corresponding to a convention or shared tradition and are often differentiated according to musical style and form

*Music imagery:* is the **music feature** of hearing music when none is externally present, meaning consciously hearing an 'inner' mental portrayal of music

*Music therapy:* is the use of music in clinical and evidence-based research and interventions by an accredited musical therapist. Applications include treatment for; MH disorders, dementia, disorders of consciousness, and movement disorders such as Parkinson's disease

*Motor processes:* are brain and cognitive functions used to produce and control motor movements, actions and behaviours in the body

**N**

*Neuroimaging techniques:* neuroimaging refers to the process of creating structural images or documenting neuronal activity in the brain and nervous system through techniques such as electroencephalogram (EEG), magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and so on

*Neuroplasticity:* also called 'brain plasticity', refers to the brains ability to change throughout life; experiences (particularly learning behaviours and brain damage) enable the brain's capability to form new and reorganise existing synaptic connections, altering brain processes

*Nostalgia:* the positive, affectionate, and wistful desire towards a previous experience

**O**

*Obsessive compulsive disorder (OCD):* a frequent **mental health disorder** whereby patients repeatedly experience obsessive (negative and unwanted) thoughts, images or urges that evoke anxiety and disgust; followed by compulsive (repetitive) behaviours that compelled to complete for temporary relief of negative emotions due to obsessive thoughts

*Oscillations:* are the repetitive variations in brain activity across time, forming a regular back and forth rhythm and a 'wave' of brain activity. There a five different neuronal oscillation bands including; delta (1-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta (13-30 Hz), and gamma (30-150Hz)

**P**

*PANAS short version:* refers to the ten question 'positive and negative affect scale' measuring positive and negative emotions

*Parkinson's disease:* is a long-term progressive disorder where brain areas become damaged over numerous years. Main symptoms include, slow movements, stiff muscles and a body tremor, but symptoms can also consist of insomnia, memory difficulties, anosmia, balance trouble and MH disorders

*Perception:* is the human **cognitive** capability of awareness through senses such as, sound, sight, taste and smell. It includes the identification, understanding and categorisation of sensory information to comprehend the external environment

*Physiological responses:* refers to changes in physiology (organs, body parts, etc) as a response to stimuli and include, heart rate variations, sweat level alterations, pupil dilation and many more measures.

*Pink noise:* is similar to **white noise** with random sequences of noise, but maintains energy per octave resulting in lower frequencies

*Pitch:* is the **music feature** of lowness or highness in music tones due to the speed of sound vibrations

*Prematurity:* an extensive term used to describe any neonates (babies) born before 37 weeks and is one of the leading causes of hospitalisation relating to pregnancy

*Premotor cortex:* is also called Brodmann area 6 and is within the frontal lobe. It has many purposes including processing language, memory attention, motor movements, and music

*Prolactin:* also called 'luteotropin' is a hormone important for over 300 functions in the body including, lactose production, inducing behaviours, and controlling the immune system

**Q**

**R**

*Rap:* a **music genre** developed in the 1970's by the urban African-Americans and is identifiable by its consistent, repetitive beat overlaid by quick, rhythmic, and chant like vocals

*Recognition:* the **cognitive function** of either accepting that something exists and is valid or the identifying something or someone from past knowledge

*Remitters:* in **depression** refers to those who successfully reduce symptoms for some time

*Repetitive brain stimulation:* is a type of **brain stimulation** where there a multiple 'bursts' of stimulation in repetition rather than a single pulse

*Reward behaviour:* refers to activities found to be rewarding by the individual due to increased brain activity within the reward circuit. Such behaviours include, exercise, eating chocolate, listening to music, and taking drugs

*Rhythm:* is the **music feature** of a prominent repeated pattern of movement or sounds; in music it refers to the structured patterns of repeated sounds that form different musical segments

*Rock:* is a popular **music genre** that evolved from simpler ‘rock and roll’ music in the 1960’s, mainly as anti-bureaucracy messages and musical experimentation

*Rumination:* in **depression** refers to patients who continually and maladaptively think about something negative

**S**

*Schizophrenia:* a severe long-term **mental health disorder** consisting of psychosis resulting in the inability to distinguish thoughts from reality. Symptoms include; alterations in personality and behaviour, reduced self-care, hallucinations and delusions

*Self-harm:* the behaviour of someone purposefully inflicting injuries or damage on them-selves typically as a mechanism for expressing or coping with emotional distress

*Self-reflective functions:* refers to behaviours that are induced by thought contemplative of the self and self-improvement

*Sensorimotor processes:* is the function where sensory information processed is combined with a related central nervous system motor response that can be reflexive or voluntary

*Skin conductance:* also called ‘galvanic skin response’ and ‘electrodermal response’ refers to the **physiological response** when skin becomes temporarily more conductive due to sweat changes in response to arousing stimuli

*Sound intensity:* refers to the **musical feature** of strength or potency in musical sounds which are measurable

*Sound sequences:* a **music feature** referring to a scripted series of sounds that is played in some sequential order

*Standard treatment:* refers to the typical forms of treatment often applied to MH disorders and includes, counselling, drug treatment, and CBT

*Stress:* can be a **mental health disorder** and is cognitive and emotional tension or strain emerging from negative, challenging and exacting situations

*Speech:* is a **cognitive ability** of communication employed particularly by humans, using vocalised sounds to articulate meaning, opinions, emotions and ideas

*Stroke:* is a serious condition where blood within the brain is restricted, resulting in malnutrition in specific brain regions, cells dying and consequences such as disability, brain injury, and death. There are different types of stroke; ‘ischaemic or embolic’ due to a blood clot and ‘haemorrhagic’ due to a weakened blood vessel wall bursting

*Suicidal thoughts:* refers to thoughts and beliefs of wanting or perceiving things will be better off if they died, also includes specific thoughts of how would kill themselves

*Superior temporal gyrus:* is one of three gyri in the temporal lobe and referred to as Brodmann area 22. Its main purpose is in auditory processing, especially speech and music

*Supramarginal gyrus:* is within the parietal lobe and referred to as Brodmann area 40. Its main functions are in emotional and music processing

**T**

*Techno:* is a specific kind of 'electronic' **music genre**, first formed in the 1980's in the US, but did not be referred to as a separate music genre until 1988

*Tempo:* is the **music feature** of speed in which music is and should be played at

*Timbre:* is a **music feature** similar to **tone** and characterised by the quality of musical sounds

*Tone:* is a **music feature** used to describe the expression of music referring to **pitch** and **intensity**

*Transcranial direct current stimulation (tDCS):* is a **brain stimulation** technique using electrodes on the scalp to administer low direct currents to specific brain regions

*Transcranial magnetic stimulation (TMS):* is a **brain stimulation** method where a magnetic coil is placed on the scalp near the interested brain area. The coil alters the magnetic field, inducing an electrical current in a small brain area through electromagnetic induction

*Traumatic brain injury (TBI):* is a particular type of brain injury which has been elicited by trauma to the head and can range from mild, moderate to severe

**U**

**V**

*Valence:* the counterpart to 'arousal' in exploring emotions, and refers to the extent something is evaluated as attractive and positive or aversive and negative

*Voxel-based morphometry:* is a **neuroimaging technique** that's maps focal volume differences within the brains anatomy and structure

**W**

*White matter:* is a type of brain tissue consisting of axons joining different regions of **grey matter**

*White noise:* refers to seemingly random noise consisting of numerous frequencies but equivalent intensities

*Working Memory:* is a sub-section of short-term **memory** and consists of the temporary storage of limited information to aid instant processing and behaviour, such as decision-making

**X**

**Y**

**Z**

# 9 Appendix

Refer to the supplementary file for appendices.