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Neurophysiological activity during music therapy with individuals with dementia

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Abstract

Music therapy is becoming widely recognised as an effective non-pharmacological therapeutic modality in dementia care, offering psychological, social, and physical benefits. However, little is known about the neurophysiological activity during active and receptive music therapy methods for persons with dementia. This may shed light on client experiences, particularly those with limited external responses. In this pre-experimental pilot study, a group of healthy older adults (n=5) and persons with mild-moderate (n=8) and severe dementia (n=5) received once-off individual music therapy sessions including receptive and active techniques during which heart rate (HR), respiration rate (RR), and electroencephalogram (EEG) responses were recorded.

There was a general increase in HR from baseline resting measures and nonparametric tests showed significant changes during singing a familiar song (p=0.044) and drumming (p=0.019). An increase was also observed during vocal improvisation. RR was highly variable as it was influenced by singing. The largest increase occurred during drumming. The autonomic data suggest that active music therapy techniques may induce greater physiological arousal than receptive techniques but this requires further investigation. Findings were minimal for the prefrontal cortex EEG; however, there were significant limitations in the acquisition and analysis of this data. There was an unexpected decrease in Gamma power for participants with severe dementia during the drumming exercise, which may implicate the Default Mode Network (DMN). Four case examples are presented in the discussion that illustrate significant moments within the sessions and relate these to the real-time neurophysiological data. These case examples highlight the differences in engagement between participants with mild-moderate and severe dementia and explore several instances of the neurophysiological data that bring insight into participant experiences as well as the shortcomings of the neurophysiological data.

Whilst the findings were modest, this research offers insight into the challenges and limitations of experimental research in music therapy and dementia. This dissertation reflects on the limitations of neurophysiological investigations of active music-making and the challenges of the dual researcher-therapist role. It critiques the ecological validity of protocolised music therapy and the use of purely quantitative methodology in music therapy research.

Keywords:

Neurophysiological activity
Dementia
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Active music therapy
Receptive music therapy
Heart Rate
Respiration
EEG

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List of Abbreviations

ABC-DS	ABC Dementia Scale
AD	Alzheimer's Disease
ADLs	Activities of Daily Living
ANS	Autonomic Nervous System
DE	Drumming Exercise
DMN	Default Mode Network
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
EEG	Electroencephalogram
FL	Familiar Listening
FMT	Frontal Midline Theta
FS	Familiar Singing
HR	Heart Rate
HRV	Heart Rate Variability
Hz	Hertz
MMSE	Mini Mental State Examination
MRI	Magnetic Resonance Imaging
PNS	Parasympathetic Nervous System
RR	Respiration Rate
SNS	Sympathetic Nervous System
UL	Unfamiliar Listening
VI	Vocal Improvisation
μV^2	Microvolts Squared

Chapter 1: Introduction

1.1 Background and Context

My belief that music therapy is beneficial and can offer profound experiences for people with dementia has led me to become passionate about research into this area. Clinical practice varies according to the needs of clients associated with dementia of different stages, particularly those in the later stages where communication and external responsiveness is greatly impaired. The often limited external responsiveness displayed by persons with more advanced dementia can be challenging for those working with this client group. It may be difficult to sense what a client is experiencing and whether or not they are aware of the music. Whilst this is also challenging for music therapists, music therapy is a particularly useful intervention for these clients as it can facilitate communication and connection even for those who can no longer communicate verbally. Even in clients who may still respond externally and verbally, there may be aspects of their experience that are not communicated. Music therapy is a largely evidence-based practice and relies on theory and research to inform approaches and techniques. Therefore, greater insight into what clients are experiencing internally on a neurophysiological level would be valuable for clinical practice. Curiosity about these internal experiences was the motivation for the design of this study.

Dementia refers to a group of degenerative diseases characterised by a gradual decline in neurocognitive functioning particularly in the cognitive domains of memory and learning, but may also include others such as language, behaviour and social cognition (American Psychiatric Association, 2013). The fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) has renamed dementia as major or minor neurocognitive disorder, depending on the severity (American Psychiatric Association, 2013). For the purpose of continuity within the wider literature, dementia will be used instead of major neurocognitive disorder. It is diagnosed based on medical history, genetic testing for associated biomarkers, neurological tests that assess cognitive functioning as well as any clinical symptoms that the individual is presenting with (American Psychiatric Association, 2013). Further discussion of the various types and causes of dementia will be provided in the literature review.

Currently there is no cure for dementia, therefore treatment is mostly symptomatic. Pharmacological treatments are mildly effective in slowing down the process of cognitive decline and reducing some behavioural symptoms, however many patients do not respond to the medications (A. Kumar et al., 2015). Whilst pharmacological treatments can assist in managing some symptoms they often carry a range of unpleasant side effects. Therefore, there is a movement to explore non-pharmacological treatments and music therapy is becoming a more sought after choice (Meyer & O'Keefe, 2018).

1.2 Significance of the Study

The body of literature is rapidly growing, however there is a significant gap in terms of the main questions this study aimed to answer. Firstly, neurophysiological activity that occurs during music therapy sessions has not been explored for persons with dementia. Most research has assessed the effects post-intervention, typically after a longer-term course of music therapy. Understanding the activity that takes place within sessions is highly beneficial for informing music therapy practice. Secondly, music therapy research concerning dementia has investigated a sample of mixed severities (i.e. not examining the role that the disease progression plays) or been limited to only one severity level. Music therapists work with clients across all stages of dementia and would therefore benefit from an understanding of the potential similarities and differences between the severity levels. The role of clinical research should be to advance clinical practice.

1.3 Research Questions

This study aimed to answer the questions:

- What are the neurophysiological responses to music therapy components in participants with and without dementia?
- To what extent does the severity of dementia mediate neurophysiological activity during exposure to music therapy components?
- To what extent do results differ between the individual components of the music therapy intervention?

1.4 Outline of the Study

Eighteen participants each received a once-off music therapy intervention consisting of five components that represent a range of typical music therapy techniques. The components were:

1) Listening to an era-familiar piece of music
2) Listening to an unfamiliar piece of music
3) Singing a familiar song
4) Unstructured vocal improvisation
5) Structured drumming exercise

Participants were divided into three groups according to absence or diagnosis of dementia. Group A consisted of five participants with no diagnosis or apparent symptoms of dementia – hereon referred to as the “healthy ageing” group. Group B consisted of eight participants with probable dementia of a mild to moderate severity and group C consisted of five participants with severe dementia. During the intervention participants wore wireless devices that measured neurophysiological activity to assess heart rate (HR), respiration rate (RR) and electroencephalogram (EEG) activity.

Chapter 2: Literature Review

2.1 Introduction

This section will situate the various aspects of the study within the existing body of literature. I will firstly provide more detail on the various types of dementia and their clinical features. I will then provide an overview of the coverage of dementia within music therapy and general music research. This will be followed by an explanation of neurophysiological parameters and an overview of related music therapy research. I will then situate the music therapy components that were used in the intervention within the neurophysiology research. To conclude I will identify and discuss the gaps in the literature that the study aimed to address.

2.2 Ageing and Dementia

The transition into the later stage of life brings with it many personal changes: psychological, social, and physical. These changes may be gradual and manageable, allowing one to function independently, however they may be more severe, resulting in dependence and the need for full-time care. Perhaps the most significant of these challenges is the development of dementia. Care is required often due to cognitive decline that affects a person's ability to function independently and care for themselves. The prevalence of dementia within long-term care facilities is high. It is estimated that 70% of residents have some form of dementia (Zimmerman et al., 2014).

2.2.1 Diagnostic Features of Dementia

Dementia is a neurological degenerative syndrome that is generally acquired after the age of 65, though can also have an earlier onset (American Psychiatric Association, 2013). In 2015, it was estimated that 47 million people had dementia worldwide and that by the year 2030 this will increase to 66 million people (Prince et al., 2015). The prevalence within low- and middle-income countries is growing rapidly. There is limited data for the prevalence of dementia in South Africa, and in Africa in general. In a small study, de Jager et al. (2017) estimate that 7.8% of adults over 65 have dementia. More larger-scale and nationwide research is needed to get an accurate prevalence.

There are a number of physical health conditions that cause, or are associated with, dementia. It is a syndrome in that the underlying cause or pathology can often be determined (American Psychiatric Association, 2013). Diagnostic criteria for the various types of dementia are based on impairment in specific cognitive domains. The criteria according to the DSM-5 (American Psychiatric Association, 2013) are outlined in Table 1.

Table 1: Cognitive domains impaired by dementia

Complex attention	• Sustained attention • Divided attention • Selective attention • Processing speed
Executive function	• Planning • Decision making • Working memory • Responding to feedback/error correction • Overriding habits/inhibition • Mental flexibility
Learning and memory	• Immediate memory • Recent memory (free recall, cued recall and recognition memory) • Very long-term memory (semantic, autobiographical, implicit learning)
Language	• Expressive language (naming, word-finding, fluency, grammar and syntax) • Receptive language
Perceptual-motor	• Visual perception • Visuoconstructional • Perceptual-motor • Praxis
Social cognition	• Recognition of emotions • Theory of mind

In addition to cognitive difficulties, individuals with dementia may experience behavioural and mood disturbances. Table 2 outlines the most common etiological subtypes of dementia, their typical clinical presentation and prevalence among dementia cases (American Psychiatric Association, 2013).

[Table 2 follows]

Table 2: Types of dementia

Etiological subtype	Clinical presentation and diagnostic features	Prevalence
Alzheimer’s Disease	• Insidious onset • Impairment in memory and learning • Gradual progression of cognitive and behavioural symptoms • Later stage: psychotic features, motor disturbances	60% - 90%, depending on the setting and diagnostic criteria.
Vascular Disease	• Onset related to cerebrovascular event (i.e. stroke) • Deficits in attention	20%
Frontotemporal Lobar Degeneration	o Insidious onset o Gradual progression of behavioural and personality change and/or language impairment o Cognitive decline less prominent **Behavioural variant:** o Decline in social cognition. o Behavioural disinhibition. o Perseverative, stereotyped or compulsive/ritualistic behaviour. o Hyperorality and dietary changes. **Language variant:** o Decline in language ability	5% (Behavioural variant and semantic language variant higher among males. Non-fluent language variant is higher among females.)
Lewy Body Disease	• Insidious onset • Gradual progression • Fluctuating cognition with pronounced variations in attention and alertness. o Visual hallucinations • Cognitive decline followed by parkinsonism	2-30% Lewy bodies present in 20-35% of dementia cases

These subtypes may overlap and coexist. For example, those with Alzheimer’s disease (AD) may also suffer a cerebrovascular event resulting in symptoms related to vascular disease. Lewy bodies, which are deposits of proteins in nerve cells, are also found in 20-35% of dementia cases, particularly AD subtypes. These mixed dementias make diagnosis and treatment complex (American Psychiatric Association, 2013).

2.2.2 Treatment

There is no cure for dementia. Medication may be prescribed to temporarily ameliorate or temporarily stabilise symptoms by improving mood, behaviour and cognitive function, however they do not prevent the progression of the disease. Moreover, these medications often come with unpleasant side effects.

Non-pharmacological treatments may offer greater effect and impact on the wellbeing and quality of life for people living with dementia. Physical activity for example may reduce the risk of other physical health conditions, support cognitive and physical functioning, and reduce or prevent mental health problems such as depression (Kwak et al., 2008). Cognitive interventions focussing on cognitive stimulation such as through reminiscence discussions, puzzles and word games, gardening, and baking can improve memory and thinking performance as well as overall quality of life (Woods et al., 2012). Occupational therapy to support daily functioning in activities may help manage and preserve aspects of an individual's functioning and therefore promote a sense of independence and competence (Gitlin et al., 2009).

2.3 Music Therapy and Dementia

Music is a powerful sensory stimulus. It is engaging, evokes emotion, stimulates physical activity, has personal meaning, and invites social interaction and connection (Thompson & Schlaug, 2015). It is widely reported in the literature that persons with dementia often respond positively to music, with personally significant music said to 'awaken' those with dementia (Baird & Thompson, 2019). Whilst music experiences may be therapeutic, without the involvement of a music therapist, these are not necessarily considered music therapy. Music therapy is a registered health profession in South Africa and many other countries. A music therapist's focus is on meeting the client's psychological and social needs through the use of, or aided by, music whilst developing a therapeutic relationship (Bruscia, 2014). Music therapy may take place in group or one-to-one settings depending on the client's needs. Individual music therapy focuses directly on the client's specific needs whereas group sessions need to cater for all clients and their shared needs. Whilst non-music therapy interventions should not be considered lesser than clinical music therapy interventions, it is important to differentiate between the two in order to maximise the benefit for the people who receive these music-based interventions. The results of a music therapy study may not be generalisable to all music-based interventions.

Several meta-analyses have assessed the benefits of music therapy and found positive outcomes in emotional, social, behavioural, cognitive and physiological domains (McDermott et al., 2013; Vasionytė & Madison, 2013). For example, group music therapy has been found to reduce symptoms of depression in persons with dementia (Chu et al., 2014; Guétin et al., 2009; H.-C. Li et al., 2019). The evidence for the efficacy of music therapy is mixed, though it is widely acknowledged that this may be due to methodological issues such as small sample sizes, different music therapy protocols and outcome measures (Lipe & Edmonston, 2020; McDermott et al., 2013; van der Steen et al., 2018).

Music listening is a commonly used activity for persons with dementia. Randomised control trials investigating the benefits of daily personalised music listening programmes for persons with dementia found significant improvements in sleep quality, social participation, and positive emotions as well as a reduction in depressive symptoms (Huber et al., 2021; Weise et al., 2020). In another randomized controlled trial, Sakamoto et al. (2013) compared the physiological and psychological effects of passive (listening to recorded music alone), interactive (listening to recorded music with a facilitator and doing hand-clapping, singing and dancing) and no-music conditions in persons with severe AD. Both passive and interactive music interventions reduced physiological stress by inducing short-term parasympathetic dominance. However, it was the interactive music condition that caused the greatest improvement in emotional state. This suggests that whilst listening to music alone does have benefits, the social aspect of music can enhance these benefits.

Community music therapy initiatives focusing on group singing have found positive results for older adults and persons with dementia such as promoting social connection, reducing isolation and improving quality of life (Hara, 2011; Lesta & Petocz, 2006). Cho (2018) found that a music therapy group singing intervention improved quality of life and positive affect for persons with dementia when compared to a music-medicine listening group facilitated by nursing staff and a television-viewing control group. Only the music therapy group showed improvement in quality of life and affect.

Music therapy sessions typically involve a range of receptive (i.e. music listening) and active (e.g. singing, improvisation) techniques, with the combination and flow determined by the client's needs. Hsu et al. (2015) conducted a randomised controlled trial to investigate the effect of individual music therapy for persons with a range of dementias. Sessions incorporated techniques such as singing familiar songs, vocal and instrumental improvisation as well as reminiscence discussions, which were found to improve wellbeing and reduce behavioural and psychological symptoms of dementia (such as agitation, anxiety, depression and disruptiveness) compared to a standard care control group whose symptoms became worse over time. Ridder et al. (2013) conducted a similar study, where sessions also involved a range of techniques adapted for each individual and found that five months of individual music therapy reduced agitation and disruptiveness and prevented medication increases in people with dementia.

Improvisation is a central tool for many music therapists. Improvisational music experiences can help persons with dementia become oriented to reality and time, offering a mindful experience where they are present and focused on the musical task, aware of themselves and of their interaction with the therapist (Parsons, 2019). Instrumental improvisation may be particularly important in the later stages of dementia when an individual may no longer be able to participate in activities such as singing. Rhythmic activities, therefore, allow individuals to participate meaningfully regardless of ability (Clair et al., 1995).

2.3.1 Memory for Music in Dementia

Music is strongly linked with memory. Firstly, music plays a role in everyday life throughout our lives (DeNora, 2000) therefore it is often associated with past personal experiences and life events occurring at the time of listening (Baumgartner, 1992). Secondly, exposure to music can assist in recall of autobiographical memories. Irish and colleagues (2006) found that persons with mild AD had significantly better autobiographical memory recall abilities when exposed to music-listening in comparison to a sustained attention task. El Haj et al. (2012) also assessed autobiographical memory recall and mild AD and found that performance was significantly better after listening to music in comparison to silence. Furthermore, participants performed best after listening to music they had chosen as opposed to the prescribed piece. Baird et al. (2020) conducted one of the first studies investigating the effect of music listening on autobiographical recall with persons with non-Alzheimer's disease dementia. They compared healthy ageing, AD and frontotemporal dementia and found that in comparison to healthy ageing, persons with frontotemporal dementia recalled significantly fewer autobiographical memories during music listening. Persons with AD were not significantly different from the healthy group. Whilst music therapy has the potential to offer persons with dementia experiences of accessing and sharing autobiographical memories, this might vary according to the type of dementia.

Recent research into music and dementia has also focused on memory for music. Despite a decline in the functioning of memory, the ability to recognise familiar music seems to remain intact (Cuddy et al., 2012; Cuddy & Duffin, 2005; Kerer et al., 2013; Samson et al., 2012). Kerer et al. (2013) found that participants with mild cognitive impairment and mild AD could indicate recognition as well as perceive distortions in familiar melodies, however struggled to name titles or composers. Samson et al. (2012) found similar results with the additional observation that musical learning is impaired in mild to moderate AD. Participants were unable to recall initially unfamiliar melodies after they had been repeated three times and at 24 hours after first testing. Cuddy et al. (2012) found several differences in musical memory abilities between participants with mild, moderate and severe AD. Whilst long-term memory for familiar melodies was preserved in mild and moderate groups, the severe group showed a decline with only a few participants able to recognise familiar melodies. Furthermore, the ability to sing a melody when prompted with lyrics was only retained by the mild group and declined significantly in moderate and severe stages. This literature suggests that long-term memory systems involved in storing musical memories are spared in many people with AD, however verbal memory for music is impaired.

2.4 Neurophysiological Parameters

Neurophysiological research focuses its investigations on the functioning and activity of the nervous system. It is a broad area of study that explores a variety of physiological systems. For the purpose of this review, I will discuss the components that are relevant to the current study.

2.4.1 Heart Rate

Heart rate (HR) is calculated by taking the average number of heartbeats in a specific time period, typically the number of beats per minute. HR is controlled by the autonomic nervous system (ANS). The ANS is responsible for automatic functions and maintaining homeostasis. The ANS can be divided into two separate systems: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The SNS is involved in increasing levels of physiological arousal whilst the PNS is responsible for decreasing levels of physiological arousal (Schneck & Berger, 2006). Activity in these systems can indicate levels of psychological arousal and stress (Berntson et al., 2007).

HR is a simple measure of cardiovascular activity and as a result, may provide limited information for interpretation. For instance, increased HR could be caused by an “increase in sympathetic activity, a decrease in parasympathetic activity, a combination of both, a sympathetically dominated coactivation, or a parasympathetically dominated coinhibition” (Berntson et al., 2007, p.204). However, when examined alongside other physiological measures HR can still be valuable. In the field of psychophysiology it is generally recognised that more insight can be gained from examining the activity across physiological parameters as opposed to responses within a single parameter (Berntson et al., 2007).

It should be mentioned that the majority of studies on cardiovascular activity during musical experiences and in dementia populations have examined heart rate variability (HRV), which refers to the variation of lengths of time between heartbeats. The time between heartbeats naturally varies as the cycles of the heart (i.e. HR) are influenced by the brain and other physiological factors (Berntson et al., 2007). The greater the variation the lower the levels of SNS activity.

Average adult resting HR ranges between 60 and 100 beats per minute. Women typically have higher resting HR. Ahmed et al., (2017) found that in comparison to healthy control participants and those with AD, participants with frontotemporal dementia had higher resting, stressed and sleeping HR. Lower HR typically indicates better cardiovascular health and it is often the purpose of medications used in the treatment of hypertension and heart disease to reduce heart rate (Materson et al., 1998). Hypertension is a cardiovascular condition characterised by high blood pressure, which can lead to severe heart disease and complications including vascular dementia. Studies have also linked hypertension to the development or worsening of other types of dementia including AD (Tzourio, 2007).

2.4.2 Respiration

Respiration rate (RR) indicates the number of respiratory cycles (i.e. inhalation followed by exhalation) per minute. One should be cautious of over-interpreting the psychophysiological indications of respiration, nevertheless, it can provide insight into states of arousal (Lorig, 2007). Furthermore, respiration is highly linked with heart rhythm. During inhalation HR increases and during exhalation heart rate decreases. This interaction is referred to as respiratory sinus arrhythmia. When the body is in a state of physiological arousal and HR is elevated, slow deep breathing can engage the PNS and assist in reducing HR (Berntson et al., 2007). Therefore researchers should observe and consider respiration as an “intervening variable” (p.231) in heart rate (Lorig, 2007).

2.4.3 Electroencephalogram

The Electroencephalogram (EEG) is a non-invasive method that measures electrical activity in the brain. Electrodes placed on the scalp detect oscillatory rhythms more commonly referred to as brainwaves (Pizzagalli, 2007). Brainwaves are categorised by their frequency, which refers to the rate at which a wave cycles or repeats in a 1 second period measured in Hertz (Hz). When comparing the activity of the various waves, the amplitude or spectral power can be analysed in order to understand the magnitude or intensity of the activity (Pizzagalli, 2007).

Pizzagalli (2007) outlines five main types of brainwaves, their frequencies, and associated mental states:

- Delta waves (δ 0.5 – 4 Hz) are typically associated with sleep states.
- Theta waves (Θ 4 – 7.5 Hz) have been observed when daydreaming, imagining, or meditating.
- Alpha waves (α 8 – 13 Hz) can reflect a resting state where the person is calm, relaxed or not engaged in focused attention.
- Beta waves (β 14 – 26 Hz) indicate alertness and focus on an activity.
- Gamma waves (γ 30 – 45 Hz) are associated with increased brain activation.

EEG can measure electrical activity across the entire cortex, which allows for the mapping of activity in different regions across both hemispheres. However, its ability to map activity in deeper subcortical brain structures is limited (Pizzagalli, 2007). The number of electrodes varies in research. High-density measurement requires 64-256 electrode sites, however fewer electrodes can still be used depending on the needs of the research. For this study, two electrodes were placed in the prefrontal cortex region as this is a particular area of interest, which will be explored further in section 2.5.2 and 3.4.3.

Delta and Theta are considered slow waves. Delta (0.5-4Hz) is the slowest wave. It is best observed during sleep, but it is also associated with states of deeper relaxation in waking states. However, increases have been observed in certain states of cognitive focus, particularly in frontal regions. Theta (4-7.5Hz) is typically associated with drowsiness, states of lower consciousness and becomes more present during sleep (Pizzagalli, 2007). However, another form of Theta, found mostly in frontal and midline areas, is associated with increases in focus and creative processes (Ishii et al., 2014; Pizzagalli, 2007; Sammler et al., 2007). Frontal midline Theta (FMT) activity may also indicate an increase in PNS activity as it is positively associated with increased HRV and negatively associated with decreased HRV (Takahashi et al., 2005). Therefore observation of FMT may serve to complement cardiovascular data. Ageing and dementia have been associated with increases in Theta and Delta wave power compared to younger controls (Sanei & Chambers, 2013; J. Wang et al., 2017).

Alpha (8-13Hz) waves are dominant in waking restful states, however it attenuates significantly when the eyes are open (Pizzagalli, 2007). Therefore, investigating Alpha activity in eyes-open conditions is challenging. Alpha power is generally greater in the posterior regions of the brain (Sanei & Chambers, 2013). Alpha increases in relaxed states, therefore an increase in Alpha activity is suggested to reflect a decrease in brain activation (Sammler et al., 2007; Schmidt & Trainor, 2001). Ageing has been associated with decreased Alpha power (Sanei & Chambers, 2013).

Faster wave activity has been associated with increased brain activation and cognitive processing. Beta (14-26Hz) is associated with alertness, focused attention and cognitive processing in frontal regions (Fernández et al., 1995). It is the dominant frequency in wakeful states where a person has their eyes open and attention is focused on the external environment (Sanei & Chambers, 2013). After the age of 50, Beta power is found to generally increase (Sanei & Chambers, 2013). Like Beta, activity in the Gamma band (30-70Hz) is associated with high cognitive demand and processing (Fitzgibbon et al., 2004). However, Gamma indicates a more elevated state of arousal and attention and is less common or dominant than Beta. There is evidence for age- and dementia-related changes in Gamma power. Gamma activity has been found to be elevated in persons with AD compared to healthy age-matched control (van Deursen et al., 2008). However, Gamma power has been found to reduce with age in healthy older adults (Murty et al., 2020).

Whilst EEG allows for more movement than other neuroimaging methods, such as magnetic resonance imaging (MRI), the electrical signals and readings can be easily interfered with by a number of factors. Some movements and behaviours may create readings that resemble waveform patterns originating from neural activity – these phenomena are referred to as artefacts (Pizzagalli, 2007). For example, neck and jaw muscle activity, as well as general body movements, can be confused with slow-wave (i.e. Delta and Theta) activity. Opening and closing of the eyes can also impact signal readings particularly with Alpha rhythms, which can appear to be significantly reduced when the eyes are open. Blinking can produce electrical signals that resemble fast-wave activity in frontal regions (Pizzagalli, 2007). Therefore, it is ideal for participants to have their eyes closed and remain still as far as possible. However, this can be very limiting in a research environment. Fortunately, there are methods of signal analysis that allow for the removal and identification of these artefacts (Pizzagalli, 2007; Sanei & Chambers, 2013).

2.5 Neurophysiological Effects of Music

Listening to music has the potential to influence both the autonomic and central nervous systems. The field of psychophysiology and neuroscience has become particularly interested in understanding the processing and effects of music listening on the body and the brain. Research is emerging in relation to the neurophysiological responses of persons with dementia.

2.5.1 Cardiovascular and Respiratory Changes

Listening to music has been found to affect HR. Etzel et al. (2006) investigated cardiovascular and respiratory responses to a range of pieces that were chosen to induce specific emotions. Physiological measures did not correlate with the targeted emotions, however they did correlate with the characteristics of the music. HR and RR were affected by tempo where, for example, longer breaths and HR deceleration were observed during pieces with a slower tempo and shorter breaths and HR acceleration during faster tempos. Lingham and Theorell (2009) found that participant-selected stimulating music increased physiological arousal whereas sedative music elicited a more subtle but still significant increase in HR. Way (2017) found that rhythmic stimuli (metronome beats) influenced participants' HR by entraining to the tempo of the metronome, which was set 7%, 10% and 15% lower than each participant's resting HR. Therefore the mood and tempo of music can influence HR and RR.

Music may be a particularly powerful sensory stimulus for persons with late-stage AD, where attention and awareness are impaired. For example, Norberg et al. (2003) found that exposure to music elicited the greatest physiological and behavioural responses (HR, RR and body movement) from patients in very late stage AD in comparison to touch and object presentation. The authors suggest that this indicates more intensive listening and awareness when exposed to music, particularly as participants seemed unaware of the objects being presented. Unfortunately the sample consisted of only two participants, however, the findings are interesting and therefore motivate for further research.

2.5.2 Neurological Changes

Music is able to stimulate the whole brain. Processing requires interaction between neural structures and networks: from temporal regions where auditory information is first encoded and deeper sub-cortical structures involved in processing rhythmic information, to sensory areas in the posterior regions involved in awareness and integration of sensory information and medial and frontal cortical regions highly involved in memory and emotion (Janzen & Thaut, 2019). This whole-brain activation makes music a powerful stimulus and experience, particularly for persons with neurological damage as areas that remain intact can still be made use of. For example, in the case of AD where memory may be severely impaired, auditory and rhythmic processing remain intact (Ferreri et al., 2019).

Electrical activity in the brain changes in response to music. Music experienced as 'pleasant' has been associated with increases in relative EEG Theta power (Ramos & Corsi-Cabrera, 1989) and specifically FMT (Sammler et al., 2007). Frontal Alpha power has also been shown to be affected by different emotional qualities of music, namely an increase in left frontal Alpha activity during ‘happy’ and ‘joyful’ music and an increase in right frontal Alpha activity during ‘sad’ and ‘fearful’ music (Schmidt & Trainor, 2001). The type of music can therefore impact electrical activity in the brain. Verrusio et al. (2015) found a differentiated EEG response to Mozart compared to Beethoven for young and elderly adults, where Alpha activity was greater after listening to Mozart. Increased Alpha indicates a more relaxed state, therefore Mozart had a more relaxing effect than Beethoven. However, adults with mild cognitive impairment showed no differentiated response. Dementia is associated with various electrophysiological changes (see section 2.4.3), therefore it is useful to explore these differences in response to music.

Listening to familiar music has been shown to improve the functional brain connectivity in persons in the early stages of AD temporarily and in the short-medium term (King et al., 2019; Leggieri et al., 2018). Impairment in the connectivity between brain regions is a feature of AD from the early stages (K. Wang et al., 2007). King et al. (2019) observed the improvement in functional connectivity directly before and after listening to a sequence of clips from a playlist of personalised music participants had been listening to regularly for 3 weeks prior to the data collection compared to unrecognisable clips. Leggieri et al. (2018) also observed improved functional connectivity measuring before and after a 3-week music listening program. These findings suggest that music listening has the potential to provide symptomatic relief from the typically reduced functional connectivity associated with AD, even in preclinical and early stages.

2.6 Music Therapy and Neurophysiology

Neurophysiological activity can indicate levels of arousal, attention and awareness (Cacioppo et al., 2007), which is of interest to music therapy practice as therapists, first and foremost, aim to make contact and communicate with the client (Wigram et al., 2002). Tomaino (2002) recommends that music therapists understand clients’ neurological processes in order to assess, plan and implement appropriate treatment. Understanding the physiological processes may also offer insight into assessment, planning and practice. Neurophysiological processes are not externally observable, therefore research investigating the internal processes is particularly beneficial for working with clients where externally observable responses may be limited, such as in the later stages of dementia.

Music therapy also shows potential for inducing positive neurophysiological changes. Suzuki et al. (2004) found improvement in levels of salivary chromogranin A – a biomarker for stress levels – as well as decreased irritability and improved language function in a sample of individuals with AD and vascular dementia taking part in 16 sessions of music therapy. Further evidence has been found for music therapy's effect on improving levels of melatonin, epinephrine and norepinephrine in AD patients, which are suggested to be responsible for lowering levels of aggression and increased relaxation (A. M. Kumar et al., 1999). Ridder (2003) found that participants with severe AD had significant reductions in HR at the end of a course of 20 music therapy sessions over a period of 4 weeks. Similarly, Raglio et al. (2010) found that persons with advanced dementia had increased, and therefore improved, HRV by the end of a 15-session music therapy programme.

An experimental study by O'Kelly et al. (2013) used a similar approach to the current study. They measured and compared the neurophysiological and behavioural activity of healthy subjects with patients in minimally conscious and vegetative states during a single-session music therapy intervention. The musical components of the intervention involved the therapist performing participants' preferred music, improvising music entrained to the participants' respiration and the particiants listening to a recorded piece of disliked music. The authors measured HRV, RR, EEG activity and behavioural observations. The patient group showed significantly less activity than the healthy group, however increases in Theta wave activity and eye-blinks were observed during the preferred music condition. The healthy group showed peak EEG responses (across all frequency bands) and increased RR during the preferred music condition. Whilst this sample differs significantly from the dementia population, the data from the healthy group remains relevant. It should be noted that this study had a number of limitations that perhaps account for the minimal responses: the patient group varied greatly in terms of pathology, were receiving medications that caused drowsiness and some had apparatus such as feeding machines that interfered with the placement of the EEG electrodes.

2.7 Neurophysiological Effects of Music Therapy Techniques

The research presented so far indicates that music therapy and music as a stimulus have the potential to induce various neurophysiological responses. Unfortunately, there is a lack of literature that explores the potential similarities and differences in responses for different music therapy techniques. Music therapy is a modality with many different approaches and models and music therapists use a wide range of techniques within sessions. This section will outline some of the main types of techniques and their associated research within neurophysiology and dementia.

2.7.1 Receptive Approaches

Receptive techniques involve the client listening to recorded music or music played by the therapist (Grocke, 2016). Receptive techniques do not indicate a passive experience. Clients may listen in silence and remain still or they may respond through movement, visual art or verbally (Bruscia, 2014). A music therapist may, for example, employ music listening for purposes of relaxation, evoking imagery, and (particularly in work with older persons) as a way of encouraging reminiscence. Whilst the majority have not been music therapy interventions, the studies presented in earlier sections illustrated the various neurophysiological effects of music listening. Music therapists are intentional in their music choice and may consider the appropriateness of the genre, mood and musical characteristics as well as the level of familiarity to the client (Grocke, 2016).

2.7.1.1 Familiarity of Music

The evidence for preserved memory for familiar music in persons with dementia provides motivation for the use of familiar music in music therapy sessions. Familiar music is useful for inviting reminiscence and triggering memories. It can serve as a way of exploring a person's life story and identity. In terms of neurophysiological responses, the current body of literature presents mixed conclusions regarding the differences between using familiar versus unfamiliar music. Ali and Peynircioǧǧlu's (2010) research suggests that familiar music elicits the greatest emotional response from listeners when compared to unfamiliar music. Weiss, Trehub, Schellenberg, and Habashi, (2016) found that familiar music was more likely to elicit physiological responses such as dilated pupils. Jagiello et al. (2018) observed similar results to Weiss et al. (2016) in terms of increased pupil dilation during familiar music, however they also found increased EEG activity during exposure to unfamiliar music.

2.7.2 Active Approaches

Active music therapy techniques involve the client physically making music. This might take the form of singing or using an instrument to play existing songs, improvise or compose new music (Edwards, 2016). Whilst there is evidence for the neurophysiological benefits of music-listening and receptive music therapy techniques, there is also evidence suggesting that active approaches to music-making may elicit a more powerful response. Nakahara et al. (2011) found an increase in physiological activity (HR, HRV and oxygen uptake) in pianists whilst performing 'emotional' pieces in comparison to listening and 'non-emotional' music conditions. Playing an instrument or singing not only involves music-perception but also motor coordination (Janzen & Thaut, 2019). Interestingly these motor areas have been shown to activate not only during performance but also when imagining performing.

In a novel study, McPherson et al. (2019) compared the effects of an active music therapy intervention (involving rhythmic movement, instrumental improvisation and listening to live music) compared to a passive intervention (40 minutes of music listening with no interaction) on HRV and salivary stress markers in healthy young adults. ANS changes were observed after the sessions where the active intervention reduced SNS activity and increased positive mood while the passive intervention increased SNS activity. The authors speculate that the enjoyable experience and physical activity involved in the active intervention lowered stress levels afterwards and that participants may have found the long listening session tiring or boring, resulting in slightly elevated stress levels after the passive intervention. Their study is the first and only to compare the physiological effects of the two approaches. However, there is still no evidence for the activity that occurs during sessions or for other client populations.

Research is lacking within neuroscience as active music-making is challenging to study because brain imaging techniques, particularly high-resolution ones such as MRI, tend to require participants to remain very still and close their eyes. However, small studies have begun to shed light on the neural processes involved in music performance, which will be discussed in the following sections.

2.7.2.1 Singing

A significant body of research has emerged relating to group or choir singing for older persons with various illnesses, in particular dementia. Group singing offers people with a range of chronic health conditions a variety of social, psychological and physical benefits, resulting in increased overall wellbeing and quality of life (Clift et al., 2018; Reagon et al., 2016; Skingley & Bungay, 2010). Therapeutic singing is a broad term for the use of singing for therapeutic goals. According to Johnson (2014), music therapists, particularly neurologic music therapists, may use therapeutic singing for speech and language goals (e.g. improving the flow and prosody of speech) and physical goals (e.g. improving the strength and endurance of vocal and respiratory systems, pacing of breathing and gait). This can be beneficial for persons with conditions such as Chronic Obstructive Pulmonary Disease, Parkinson’s disease and later stages of dementia where speech may become impaired (Johnson, 2014). Singing has been shown to activate neural networks in the temporal and sensorimotor regions that are also involved in speech (Özdemir et al., 2006). In ageing adults, including those with dementia, therapeutic singing is recommended for improving and maintaining “vocal output” as well as supporting “respiratory capacity” (Johnson, 2014, p.186).

Singing can regulate the pace of breathing as individuals use the temporal structure of the music to guide their breathing pattern (Johnson, 2014). Vickhoff et al. (2013) measured singers’ respiration and HRV during free humming of a single pitch, singing a hymn with unguided breathing and singing a repeated chant with breaths at the end of the phrase. Breathing pattern was dependent on the song structure and, in turn, influenced HRV. Furthermore, HRV became synchronised between the singers as a result of their respiration entraining. Bernardi et al. (2017) found similar effects where normal respiration was interrupted by singing. They found a moderate reduction when singing a familiar song and a large reduction (rate of six breaths per minute) when improvising on long vowel sounds.

Singing with another person involves not only musical synchronisation but neural synchronisation. Joint singing stimulates and synchronises activity in the inferior frontal cortex between the two people compared to singing alone (Osaka et al., 2015). Osaka et al. suggest that singing together may therefore be helpful for persons whose “sense of shared cooperation is weak” (p. 10) because of this neural synchronisation effect. This ‘cooperation’, could rather be termed interpersonal synchrony, which refers to a person’s capacity to coordinate and adjust themselves in relation to another during communication (Pavlicevic, 1997). This is of particular interest for music therapists, where many clients with neurological impairment may have difficulty with interpersonal synchrony (Pavlicevic, 1997), and the goal is to facilitate this through music. Therefore, this evidence of neural synchronisation during joint singing may explain experiences of interpersonal synchrony between client and therapist from a neurological standpoint.

2.7.2.2 Drumming

The use of percussion and drumming is common in music therapy practice (Bruscia, 2014). It may be used in various ways such as client and therapist playing structured rhythmic patterns in unison, layering different rhythms, using call and response and free improvisation. Group drumming is a particularly popular group music intervention both within music therapy and in community music practices, where much of the existing research comes from. A number of studies have demonstrated improved immunological functioning and reduced levels of stress hormones (Bittman et al., 2001; Wachi et al., 2007) particularly in older adults (Koyama et al., 2009). C. Smith et al. (2014) found that HR increased significantly during group drumming and improved blood pressure in older adults. This physiological data led them to classify drumming as low-to-moderate exercise.

Similarly to joint singing, a synchronisation effect has also been found during joint instrumental playing. During group drumming cardiovascular activity and movement synchronises between group members (Gordon et al., 2020). EEG activity in pairs of guitarists playing the same melody to the beat of a metronome was also found to synchronise (Lindenberger et al., 2009). Whilst there is no EEG research about joint percussion playing, it could be hypothesised that this activation and synchronisation may also occur as the client and therapist engage in simultaneous playing of rhythmic patterns.

Overall there is a lack of evidence for neurophysiological responses to drumming, particularly with regards to brain activity. There is a further gap in the knowledge around drumming in individual music therapy conditions and with persons with dementia.

2.7.2.3 Musical Improvisation

Musical improvisation is the performance of spontaneous and unprepared music, created by the musician. Improvisation used in music therapy is referred to as clinical improvisation. Wigram (2004) differentiates clinical improvisation as being "the use of musical improvisation in an environment of trust and support established to meet the needs of clients" (p.37). Improvisation is one of the four main music therapy methods proposed by Bruscia (2014) and for several models of music therapy, improvisation is the central feature. For example creative music therapy (also referred to as Nordoff-Robbins music therapy) is predominantly improvisation-based (Guerrero et al., 2016). In clinical improvisation the music therapist becomes highly attuned to the client - noticing and subsequently musically matching the quality of their energy be this through observing posture, movement, facial expressions or the music they are making (Pavlicevic, 1997a). This is the foundation of making contact and connecting to the client, even with those who may be externally non-responsive, which therefore makes improvisation a particularly suitable technique when working with clients with mid- to late-stage dementia.

There is some evidence for neurophysiological changes associated with clinical improvisation. In a pioneering study by Neugebauer and Aldridge (1998), it was found that during musical improvisation HR activity of client and therapist was highly in sync. Throughout different sections of the improvisation, ranging from instrumental playing to singing, there were indications of concurrent HR changes. In a sample of persons diagnosed with depression, Fachner et al. (2013) found reductions in symptoms of depression and anxiety accompanied by an increase in resting EEG Theta power after three months of psychodynamic improvisational music therapy.

Information can also be drawn from outside the field. Studies of jazz improvisation have found interesting results relating to activity in the prefrontal cortex. Musical improvisation has been associated with greater frontal EEG Alpha activity when compared to rote playback of melodies (Lopata et al., 2017) or scale exercises (Sasaki et al., 2019). Limb and Braun (2008) found that during jazz improvisation areas of the prefrontal cortex deactivated while motor areas became more active. They suggest this is possibly due to the role of the prefrontal cortex in self-monitoring and inhibitions and that improvisation requires creativity and often a state of 'flow', where inhibition and self-consciousness are diminished in order to increase the output of creative ideas. In a Master's thesis, Kalmeier (2016) explored flow states during live jazz piano improvisation. There was an increase in overall EEG activity, but most significantly in the Delta and Theta bands. PNS activity also increased, evidenced through increased HRV, during improvisation compared to baseline resting.

2.8 Gaps in the Literature

There are a number of significant gaps in the literature regarding neurophysiological activity during music therapy. Firstly, much of the research investigating neurophysiological responses to music consists of interventions that are purely receptive and typically use recorded music as opposed to live music-making. Therefore these findings cannot easily be generalised to music therapy interventions as music therapy encompasses a wide and diverse range of techniques. Secondly, the very limited neurophysiological research within music therapy is made up of longer-term music therapy interventions consisting of multiple sessions where change is measured after the process. There is therefore a lack of research on the experiences during sessions. Investigating the neurophysiological responses during a music therapy session may provide insight into what clients are experiencing, which is particularly valuable for client groups that may be unable to verbally communicate their experiences.

Finally, there is a lack of research with dementia populations, which therefore leads one to rely on results from healthy population groups or other unrelated clinical groups. Within the small number of studies with dementia populations, the severity level tends to be limited to a single level or include several levels that are combined instead of compared. As the disease is progressive, which results in significant impairments to functioning and structural changes to the brain, there is reason to be cautious of generalising the results from populations in one severity level to populations in other stages of the disease. The current study, therefore, aimed to address these gaps by measuring neurophysiological responses to a range of standard techniques used in music therapy sessions and the potential impact that the progression of dementia has on these responses.

Chapter 3: Methodology

3.1 Introduction

This section will firstly present the general approach and design of the study. I will provide a detailed outline of the data collection procedure including sampling, measures, and the music therapy intervention followed by a discussion of the data analysis methods. Finally, I will reflect on ethical considerations and research quality.

This study aimed to answer the questions:

- What are the neurophysiological responses to music therapy components in participants with and without dementia?
- To what extent does the severity of dementia mediate neurophysiological activity during exposure to music therapy components?
- To what extent do results differ between the individual components of the music therapy intervention?

3.2 Approach and Design

This study used a pre-experimental mixed design. Pre-experimental designs are experimental in that they measure the effects of some form of intervention but they do not qualify as true or quasi-experiments due to their lack of a control group that does not receive the intervention and random assignment, which would be needed in order to draw causal inferences (Jimenez-Buedo, 2018). This study aimed to investigate the neurophysiological activity that occurred in participants during different music therapy components and the potential mediating role of the severity of dementia. Whilst there was no control group, participants acted as their own controls. Multiple baseline measurements were taken: one before the first music therapy component began and one for each resting period between each music therapy component. Therefore, changes from participants' neutral states could be observed and analysed. In order to isolate the participant variable of dementia, a group of older adults without dementia also received the intervention.

A mixed design consists of both within-subjects and between-subjects elements (Salkind, 2010). Each participant was exposed to the same five conditions (music therapy components) and measures (HR, RR, and EEG), which are key characteristics of within-subjects designs. What additionally characterises this design as between-subjects are the differences in the severity of dementia between the participant groups. This complex design allows for a range of relationships to be investigated, resulting in rich and multi-faceted research. Whilst pre-experimental designs lack the statistical significance to confirm causal relationships, they are useful for highlighting potential relationships and, in turn, motivating for more robust research (Frey, 2018; Wheeler, 2016).

3.3 Sampling

The study sample consisted of 18 participants assigned to three groups according to severity or absence of dementia. Group A was an age-matched (over 65 years old) comparison group consisting of five participants (four female) without dementia. This allowed for the mediating variable of dementia severity to be isolated. Group B consisted of eight participants with mild to moderate dementia (seven female). Group C consisted of five participants with severe dementia (four female). The study originally aimed to focus on AD, however challenges during sampling, which will be discussed further, did not allow for this. The study was conducted at a multi-level retirement facility in Johannesburg, South Africa. The facility included independent living cottages, an assisted living unit, a frail care unit as well as a specialised dementia unit for residents with severe cases of dementia. Participants were referred to the study by the nursing manager at the retirement village. Originally a psychiatrist associated with the facility was going to refer from his own client base at the home, however this was not possible as only very few of the smaller than anticipated number of his clients were suitable for the study based on the exclusion criteria. The pool of suitable candidates was not large enough for random selection to be used for the clinical groups.

Participants in the healthy comparison group (group A) were recruited by the head of administration for the independent living village who had a good knowledge of all residents. They were informed of the inclusion and exclusion criteria and then began contacting residents in Alphabetical order until five had agreed to meet with me and take part.

3.3.1 Inclusion and Exclusion Criteria

Inclusion criteria for all participants were being over the age of 65 and fluent in English. This was necessary due to my lack of fluency in other South African languages, which possibly would have impacted sessions by limiting the ability to communicate. Criteria for the clinical groups (B and C) originally included an official diagnosis of AD and an assessment of severity by a clinician within the previous 3 months, however this was not possible. Very few residents at the facility, excluding the dementia unit, had an official diagnosis of any type of dementia. It, therefore, was also not possible to ascertain the specific type of dementia. According to the nursing manager, many residents had mild and moderate dementia but had not been diagnosed as very few have access to a psychiatrist. It is apparently uncommon for a resident to be assessed by a clinician unless they present with severe symptoms requiring more intensive supervision and care provided in the specialist dementia unit. This is perhaps reflective of the general practices within these facilities. In order to adapt to the situation I provided the nursing manager with observable criteria for dementia and differentiating between mild, moderate and severe dementia. This was based on diagnostic criteria in the DSM-5 (American Psychiatric Association, 2013), advice from a psychiatrist and using the ABC dementia scale (Mori et al., 2018), which will be discussed in more detail in section 3.3.2.

The general criteria for possible dementia were:

- Significant difficulties with memory (e.g. forgetting location of familiar items, difficulty recalling recent events and interactions)
- Difficulties with activities of daily living (e.g. dressing, washing, eating, toileting, using appliances) not due to a physical condition or general frailty
- Irritability and restlessness
- Communication difficulties (expressing needs, holding a conversation, finding correct words)

Residents with probable dementia, and estimated severity (see 3.3.2), were identified by the nursing manager using these criteria. It was not possible to arrange for the nursing manager to then compile a list and filter out those not suitable based on the exclusion criteria, which would have kept residents' information private before consent to release information could be obtained. It was a time-consuming task that staff did not have time for therefore the nursing manager suggested that I complete the process myself on the condition that residents' information remained confidential.

Exclusion criteria for all groups included diagnoses of Parkinson's disease or epilepsy, an experience of a recent traumatic event, or a recent acute medical condition requiring hospitalisation in the previous three months. Whilst it is ideal to observe participants without any lifestyle diseases such as diabetes, hypertension and high cholesterol this is unlikely to be feasible within one facility as a high percentage of older persons are diagnosed with lifestyle diseases. For example, in 2016 80% of adults over 65 in South Africa had hypertension (National Department of Health et al., 2016). Therefore participants with these conditions were accepted as long as the conditions were medically well-controlled. Residents identified by the nursing manager as having probable dementia that did not satisfy the exclusion criteria were removed from the list. This left a total of 15 residents deemed suitable for the clinical groups. Consent was obtainable from 13 residents.

3.3.2 Determining Clinical Groups

All participants in the clinical groups were evaluated using the ABC dementia scale (ABC-DS) based on staff members' responses to the scale questions (Mori et al., 2018). Due to the small pool of suitable candidates it was clear that constructing three equal-sized groups containing participants with mild, moderate and severe dementia respectively was not going to be possible. A group of five residents with severe dementia were easily identified as they were living in the dementia unit. They were evaluated using the ABC-DS to evaluate severity. Two participants in group C had official diagnoses of probable AD, one participant had a diagnosis of Vascular dementia, and the remaining two were awaiting assessment from a psychiatrist.

Residents that were not in the dementia unit were also evaluated using the ABC-DS. The nursing manager gave an estimated severity based on guidelines provided in consultation with a psychiatrist. A resident was considered mild if they presented with features of dementia outlined above (3.3.1) but did not require a great deal of supervision and were able to function independently with activities of daily living (ADLs). Moderate cases were indicated by a decline in functioning where a resident may need more assistance with ADLs (not due to a physical condition or frailty) particularly due to memory difficulties and more frequent supervision. Severe cases were indicated by a severe decline in functioning requiring constant supervision and assistance with most ADLs.

3.3.3 ABC Rating Scale

The study originally aimed to assess participants specifically with Alzheimer's disease however as discussed above it was not possible to determine the type of dementia. The ABC-DS was created as a simple tool to assess the presence and severity of Alzheimer's disease[1] (Mori et al., 2018). The scale was still used in the process of recruiting participants despite being aimed at assessing persons with AD but will not form part of the analysis due to the potential resulting lack of construct validity. However, it is still of value as it is comparable with other more general dementia scales such as the clinical dementia rating scale (Mori et al., 2018; Morris, 1993). It assesses many of the same domains, such as memory, personal care and social functioning, and does not require special training in using the scale. Due to mild and moderate cases being combined into one group the issues relating to the construct validity of the ABC-DS do not impact significantly for differentiating between mild-moderate and severe.

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[1] A user license agreement was obtained from the publisher.

The ABC-DS contains 13 questions that each use a 9-point scale (see Table 3 for question example). Caregivers are interviewed, and their responses indicate where the person being evaluated falls on the scale. Lower scores indicate lower levels of functioning. Descriptions of typical observable criteria are given at points 1, 3, 5, 7, and 9, but intermediate points (2, 4, 6, 8) can be selected where the person fulfils criteria for two points. Scores for each question are then added to form the total ABC-DS score which ranges from a minimum of 13 to a maximum of 117.

Table 3: Example question from ABC-DS

Question 2. How spontaneously does the patient perform the activities of daily living? (For example, shopping, rehabilitation/day care, brushing teeth, shaving, make-up, combing hair, getting up, etc.)	
9	**Performs spontaneously without verbal reminders**
8	
7	**Sometimes needs verbal reminders**
6	
5	**Always needs verbal reminders**
4	
3	**Sometimes does not attempt even with verbal reminders**
2	
1	**Never attempts even with verbal reminders**

The scales are challenging to use when a person has a condition affecting them physically or is very frail. Questions around personal care and daily activities had to be asked hypothetically so as not to automatically attribute lower functioning to dementia when it may have been due to the physical disability. For example, when asking staff the question “how is the resident when changing clothes?” it was necessary to ask this hypothetically if the resident was in a wheelchair or had difficulties using their arms. This introduced confusion for staff at times and could have therefore made reports less accurate.

3.4 Measures

A selection of neurophysiological parameters were measured using BioNomadix wireless physiology monitoring devices (BIOPAC Systems Inc., n.d.). These were pieces of wearable technology strapped to the torso and head that enabled real-time recording of HR, RR and EEG activity (see Figure 1). Data was streamed and captured to a laptop computer running the software *AcqKnowledge* 5.0.2 (BIOPAC Systems, In., n.d.). The Biopac devices have been used in multiple peer-reviewed publications (see Howells et al., 2012 and Prinsloo et al., 2013).

ECG and Respiration module with electrodes and stretch band | **EEG module** | **EEG reference electrode**

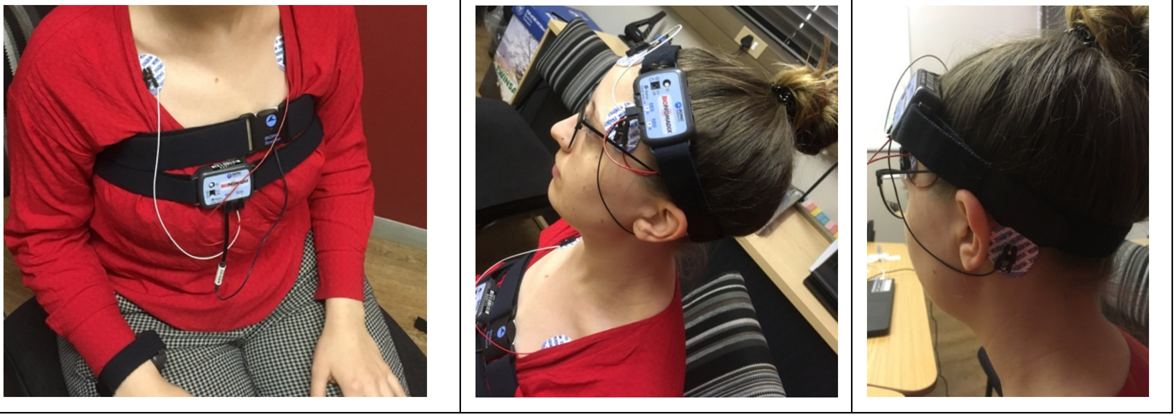


Figure 1: Photos of BioNomadix devices being worn by researcher

3.4.1 Heart rate

HR data was obtained through an electrocardiogram transmitter strapped to the chest connected to two electrodes placed below the participant's collar bones. Average HR was reported in beats per minute (BPM).

3.4.2 Respiration

RR was recorded using a band around the chest that sensed inhalations and exhalations. Respiration was reported as average breaths per minute (BrPM). A breath cycle includes inhalation and exhalation. The technology also allowed for observation of respiration characteristics – general rhythm and depth of breathing.

3.4.3 Electroencephalogram

Standard EEG devices used in medical settings require the person to remain as still as possible. This was not suitable for the proposed study as participants needed to be able to move during certain parts of the session. Restricted movement may also inhibit the participant's full engagement with other components. The BioNomadix EEG module was therefore a more appropriate option. It is wireless, lightweight, and allows for some movement whilst recording data. The EEG module was strapped around the head and electrodes were placed onto parts of the head to pick up signals of activity. This study used a single-channel quantitative EEG. Three electrodes were placed according to the international 10-20 system. The first electrode was placed on the centre of the upper-forehead at point FPZ, which refers to the central prefrontal cortex. The second was placed slightly to the left at point FP1. The single-channel (channel FP1-FPZ) represents the differences in activity between the two electrodes. The third electrode is placed as a grounding reference behind the right ear on the mastoid bone where no electrical activity should be picked up. Because of the placement, the electrodes pick up electrical activity that is occurring in the left prefrontal cortex.

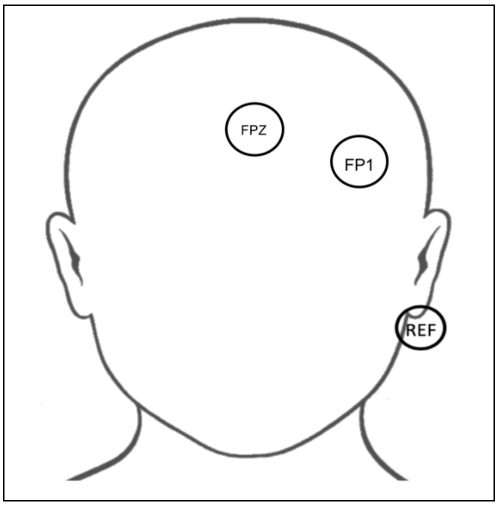


Figure 2: EEG Electrode Placement

The prefrontal cortex is primarily responsible for executive functions, such as focused attention, impulse control, cognitive processing, inhibiting inappropriate behaviour and self-monitoring. Frontal areas are particularly important in music processing as they transform acoustic information into meaningful information in terms of aesthetic qualities as well as relation to autobiographical memory and meaning (Janzen & Thaut, 2019).

3.5 Procedure

Participants each received the music therapy intervention individually. I administered the intervention whilst a postgraduate physiology student managed the technical equipment and data collection. Baseline measurements were taken at the start of the session for a short period of 2 minutes to establish a resting, no-intervention (control) state. I then carried out the intervention in the order listed in section 3.6. Real-time, continuous measurements were taken throughout the intervention. Participants were also given a 1 minute period of rest between each component during which measurements continued to be taken. It should be noted that it was not possible to get full baseline and resting measurements for some participants in group C, as they had difficulty remaining still and silent. In these cases the baseline or resting periods were terminated and the next component was initiated. Sessions were video recorded (consent was given by participants, proxies and the institution) in order to facilitate a richer discussion of the quantitative data in relation to specific moments in the sessions. The video footage was used to write session notes for each participant, noting participant and music therapist musical and non-musical behaviour, and significant moments accompanied by specific time-stamps (see Appendix A for an example). Whilst the video footage and session notes were not analysed as formal data sources, they ensured greater accuracy in the reporting of what occurred during the sessions as well as the case examples discussed in chapter 5. Each session lasted between 20 and 25 minutes in total.

3.6 Music Therapy Intervention

All participants received the same music therapy intervention structure (Figure 3). The five components were chosen to represent a range of standard music therapy techniques. I will give a detailed outline of each component and discuss any deviations from the standard protocol.

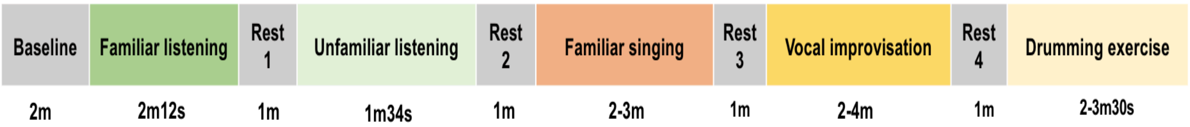


Figure 3: Session protocol

3.6.1 Component 1: Familiar listening (FL)

All participants listened to a recording of the song *'Hound Dog*' performed by Elvis Presley. The song was chosen as it is generally well-known and familiar to the era of the sample. This is based on my own experience working with this client group as well as consultation with other experienced music therapists. It is a quick and lively song (tempo 144BPM) in a 1950s rock n roll style. The song was played from a speaker at a volume not exceeding 85 dB(A). The duration of the song is 2 minutes and 12 seconds. This component represents a receptive music therapy technique.

Originally it was intended for the familiar song to be chosen by participants or recommended by family members. However, this would have required a lot more preparation time at the facility, which was not available. This also may have resulted in differing styles and tempos, which have been shown to influence physiological responses therefore using one song ensured consistency in musical characteristics.

3.6.2 Component 2: Unfamiliar Listening (UL)

All participants listened to an unfamiliar piece of classical music. It was a recent, unreleased and original piece composed and recorded by a local musician, therefore making it extremely unlikely that participants would have heard the piece before. It is a slow (tempo 65BPM) lyrical orchestral piece in a romantic style. Volume was the same as the familiar listening (FL) component. The piece lasted for 1 minute 38 seconds. This component also represents a receptive music therapy technique.

3.6.3 Component 3: Familiar Singing (FS)

Participants chose between two familiar songs: 'You are my Sunshine' and 'Amazing Grace' based on which they felt they knew better. All participants, with the exception of participant C2, showed recognition of their chosen song evidenced by their singing along. Participants were invited to sing along with me whilst I provided guitar accompaniment. The structure was the same for all participants. The component began with singing the song with lyrics, followed by singing the melody on the syllable 'la', humming the melody, a return to the melody with lyrics in a more articulated style, and finally a repeat in the original style. The initial tempo was between 80BPM and 90BPM for all participants. Tempo generally varied throughout the song for all participants as different styles were introduced or when the participant's tempo was being matched. An in-depth analysis of tempo changes was not carried out. This component represents an active music therapy technique. It should be noted that participant C2 did not sing along as they were non-verbal and did not vocalise. I sang the song 'Amazing Grace', (as suggested by a present staff member who knew the participant well) to the participant, matching my tempo to their breathing and foot tapping.

The cultural backgrounds of participants were not known for certain. However, by virtue of living in an institution where most residents' first language was English, it was assumed that the majority of participants would likely be familiar with the songs chosen. However, it is possible that the music used may not have culturally resonated in the same way for all participants. Furthermore, even within participants of shared culture there may still have been variation in the levels of preference as well as memories associated with the songs.

3.6.4 Component 4: Vocal Improvisation (VI)

I engaged with participants by inviting them to join in making spontaneous vocal sounds and melodies along to a simple guitar accompaniment at a medium tempo. I began with a vocal motif and guitar accompaniment that was the same for all participants (see Figure 4) but then improvised based on the vocal material that participants offered. Some participants did not improvise their own material and instead copied what I was singing, however this is still considered improvisation as it was an unknown melody created in the moment. In contrast, some participants offered full melodies with lyrics that were then developed by both of us as the improvisation unfolded. The activity was unstructured with a free-flowing form. As with the familiar singing (FS) component, participant C2 did not sing. I improvised vocally and matched small movements and responses given by them, which is a standard technique used in clinical improvisation (Wigram, 2004).

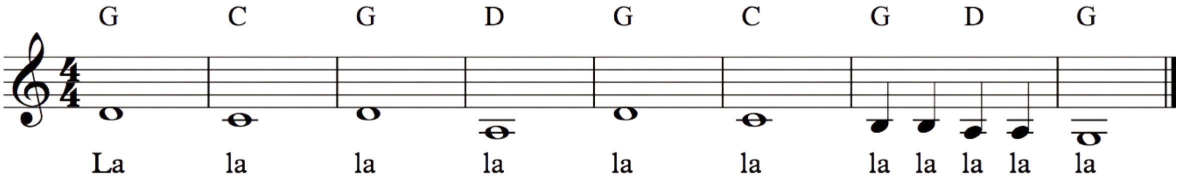


Figure 4: Initial vocal motif and guitar chord progression for VI component

3.6.5 Component 5: Drumming Exercise (DE)

I facilitated a simple drumming activity. I guided each participant in jointly playing simple rhythmic patterns and invited them to create their own rhythmic patterns and engage in call and response. I aimed for the structure to be identical for all participants however this was not possible for some participants. Those in wheelchairs were frail and needed assistance to hold the drum. I shared the drum with these participants and we each played with only one hand. I had to adapt the exercise but the elements of copying rhythms and spontaneous improvisation were kept. Participant C2 was particularly frail with limited communication, which resulted in the drumming being very minimal. I began singing a melody as it felt therapeutically appropriate in the moment – the participant had very limited movement in her hand and melody added musical interest that could not have been achieved rhythmically. This will be discussed further in chapter 5.

3.7 Data Preparation

Data was captured using Biopac's analysis software *AcqKnowledge* version 5.0.2 (BIOPAC Systems Inc., n.d.). This raw data was then transferred to excel spreadsheets and tabulated for statistical analysis. The process of data acquisition, preparation and analysis was completed by a postgraduate physiology student and external technician.

3.7.1 Respiration Rate

Average RR (breath cycles per minute) for each component, baseline and resting periods were calculated. RR was calculated by taking a 30-second segment deemed representative of the component, counting the breath cycles and multiplying by 2. Some participants had very irregular and artefactual data resulting in an average not being obtainable. These missing cases will be outlined in Chapter 4. Rhythm and regularity were also observable, though were not quantified, which will be discussed further in the discussion of the results (see Chapter 5).

3.7.2 Heart rate

Average HR (beats per minute) for components, baseline and resting periods were calculated and a value was output by the software. Some participants had very irregular and artefactual data resulting in an average not being obtainable for several participants in some components.

3.7.3 EEG

EEG activity was recorded continuously throughout the session. In order to turn the raw signal into numerical data, a number of steps were taken. This preparation was completed by a physiology technician, experienced with the software and EEG in general. Firstly, the signal required denoising by using Electrooculogram artefact removal, which removed unusual events caused by eye-blinking. A bandpass filter was added to filter out values outside the frequency cut off of 0.5Hz-45Hz, using the Hamming windowing technique. The five frequency bands were then derived from the raw EEG signal, which allowed the mean absolute power for each frequency band to be examined. Frequency bands were set to: Delta 0.5-4Hz, Theta 4-8Hz, Alpha 8-13Hz, Beta 13-30Hz and Gamma 36-44Hz. The recording was divided into 15-second intervals (epochs) and the mean average power (Microvolts squared - μV^2) was calculated for each interval. Data was exported to Excel, organised into the various components and baseline periods. The data for the resting periods were not included as this would have created a significant increase in the volume of data, which was not possible to analyse due to time and resource constraints.

3.8 Data Analysis

Data analysis involved statistical analysis of the neurophysiological data. Descriptive statistics were used such as means, medians and interquartile ranges. The sample was small and not normally distributed. Therefore, in order to compare the groups and components, nonparametric tests were used. Statistical analysis was carried out by a statistics consultant (see Appendix B).

3.8.1.1 Heart Rate and Respiration

Basic descriptive statistics were calculated for the HR and RR data. Means, medians, and interquartile ranges are reported in tabular form for each group during each component as well as the total sample for each component. Nonparametric tests were used to compare differences between groups for each component (Kruskal-Wallis test) as well as differences between the components (Friedman test) for the total sample and per group. The raw HR and RR data are included in Supplementary Appendix I and J.

3.8.1.2 EEG

Basic descriptive statistics (means, medians, interquartile ranges) were reported based on the absolute power for each frequency band (Gamma, Beta, Alpha, Theta and Delta) as well as comparative statistics, following the same process as the HR and RR data analysis, to compare groups and components. Because of inconsistencies in the baseline measure for group C, a complete session average was calculated as a supplement to the baseline. The raw EEG data are included in Supplementary Appendix K.

Two other approaches were taken in the analysis of the EEG, however the results are not reported here as they did not offer any different findings. The two approaches involved normalised the raw values against the baseline (i.e. absolute power for each component divided by baseline power value) and also the complete session average value. This was to account for individual differences and to represent changes from baseline more clearly. The complete session average was used because of the baseline inconsistencies. Neither approach yielded additional results therefore the original raw values for absolute power will be reported on.

3.9 Ethical Considerations

Informed consent is a key principle of ethical research with human participants. In order for a decision to consent to participate in research to be considered informed, several criteria must be met. A participant should be able to fully comprehend the information given regarding participation, weigh up the potential benefits and consequences of taking part and provide verbal and/or written consent (Oliver, 2003). Informed consent becomes a complex issue when working with vulnerable individuals. As dementia progresses, the capacity to provide informed consent can become compromised and therefore additional measures should be taken to protect participants (Slaughter et al., 2007). Cognitive decline can result in individuals having difficulty with understanding information, reasoning, and considering consequences. Furthermore, as memory abilities become increasingly impaired a potential participant might understand the information in the moment but may lack the ability to retain the information. Therefore, it is not possible for participants to reflect on their decision, which, according to Oliver (2003), is another key requirement for informed consent.

A diagnosis of dementia does not automatically declare an individual as lacking the capacity to make decisions such as consenting to participate in research (Hegde & Ellajosyula, 2016). It is essential to take care in examining whether or not the individual can provide informed consent. The Mini Mental State Examination (MMSE) (Folstein et al., 1975) is frequently used in assessing capacity to provide informed consent in individuals with dementia. However, Warner et al. (2008) have found that it is not always reliable in determining capacity to consent. For example, some individuals with higher MMSE scores, indicating cognitive capacity, were found through further assessment to not fulfil capacity criteria and vice versa. Therefore, it is important to also use clinical judgement and additional methods of assessing capacity. Techniques for assessing comprehension of information include asking the participant to repeat back what they have understood from the information provided to them and returning after some time has passed to re-evaluate their retention and understanding (Slaughter et al., 2007).

Another key principle of ethical research is nonmaleficence. There were no anticipated risks involved in participation in the proposed study. The music therapy intervention posed no risks and was likely to have been enjoyable for participants. It is possible that the experience of having physiological devices attached during the session may have been uncomfortable for participants. Participants were frequently asked during the setup of the equipment if they were comfortable with the procedure, if the devices were fitting comfortably and if they were happy to continue. Participants had the right to withdraw at any stage of the process should they have wished to do so.

Participants were presented with clearly explained information relating to the research process, potential risks (or lack thereof) and benefits, and their right to withdraw at any stage (Appendix C). Informed consent was obtained from participants in the non-clinical group (Group A) verbally and in written form (see Appendix D for consent form). For groups B and C written consent was obtained from a suitable proxy such as a legal guardian or close relative (see Appendix E for consent form) as well as verbal and, where possible, written assent from the participant. Some participants in group B were felt to have capacity to consent however the institution required that family members are informed and give consent regardless of capacity. Consent to conduct the study at the facility was obtained from the nursing manager (see Appendix F for consent form).

3.10 Research Quality

In order to ensure reliability, which is the consistency of results, the intervention had a standard protocol that is described in detail (see section 3.6). Furthermore, the measurement devices have been established as having satisfactory reliability as mentioned above. Due to the nature of music therapy there may be slight variation depending on the participant's needs or response. The full music therapy session, including the setting up and testing of equipment, was rehearsed with a fellow student before the study commenced. This was done in order to make sure the procedure was consistent once working with participants.

Validity is the accuracy of results and related claims being made by researchers (Frey, 2018; Salkind, 2010). The study had a number of limitations regarding external and internal validity. The small sample size, lack of a control group and random assignment give low external validity, however these are acknowledged and in the discussion of results unfounded claims have not been made regarding causality or generalisability. Due to the exploratory nature of a pilot study this is not detrimental to the results, however it should be considered when interpreting results.

Whilst it is typical to randomise or counterbalance the order of experimental components in order to prevent order effects (Frey, 2018), it was not suitable for the music therapy intervention. Therefore there is a rationale behind the chosen order of the components. For example, if the protocol began with vocal improvisation (VI) it may have been uncomfortable for the participant who was engaging with the music therapist for the first time. The possibility of an anxiety response or nonactivity would have then been more likely than if the participant began with listening followed by singing a familiar song. Therefore the VI component was placed after the listening components and the familiar singing (FS) component to allow the participant to become more comfortable.

In order to prevent or observe carryover effects, participants were given a 1-minute resting period in between each component. Measurements continued during this period with the intention of observing carryover effects. As seen in the literature, drumming is likely to increase HR, therefore the drumming exercise (DE) component was implemented last in case HR remained elevated for longer than the 1 minute, which would contaminate results. Basic descriptive statistics were produced for the resting periods for the HR and RR data. However, due to time and resource constraints the resting periods could not be included in the full statistical analysis and for the EEG data therefore it cannot be confirmed if the resting periods prevented carryover effects. Nevertheless, chances of carryover effects will have been reduced by having resting periods.

Various factors within the study design and implementation threaten its internal validity. Firstly, challenges in the participant recruitment stage resulted in potentially decreased validity. Recruiting participants with a confirmed dementia diagnosis and the inclusion of details regarding type and severity was not possible. In order for this to have been possible a clinician would have needed to assess each participant. It had been planned that a psychiatrist was going to refer participants from their existing client base however as mentioned above it did not materialise. Nevertheless, staff at the facility were well trained and very familiar with dementia and their expertise should therefore not be dismissed. In the evaluation of each participant with staff members using the ABC-DS, it was clear that all participants presented with typical symptoms such as memory loss. Regardless of whether an official diagnosis had been given, all participants in the clinical groups (B and C) can be said to have displayed symptoms of dementia. In distinguishing groups B and C there was a marked impairment in functioning.

Inconsistencies within the music therapy components and resting baseline potentially threaten both reliability and validity. As mentioned above, the baseline measurement was compromised for some participants. The familiar listening (FL) and unfamiliar listening (UL) components were identical for all participants as they sat and listened to the same pre-recorded pieces of music however the active music-making components introduced variation. For the FS component participants were given a choice between two songs to ensure that every participant knew the song well enough to sing along. Both songs were sung using the same structure (as described above in section 3.6.3). The VI component naturally brought more variation as participants differed in their responses and the music was unique and original. This brings into question how results can be interpreted if participants had different musical experiences. Some uniformity was maintained, as described in section 3.6.4, however the variations will be considered when reporting on and discussing the results. Finally, the DE component was designed to be uniform but there were some variations as described in section 3.6.5.

The most significant threat to the quality of the research is the technical difficulties caused in the data collection stage that were only revealed when preparing and trying to analyse the data. Because of the participants' movement during the session, there was a great deal of error and interference observed by the technician. Despite having processed the data to remove artefacts, it is not guaranteed that all remaining data is free of artefacts as it is a highly complex process where eye blinks, for example, can resemble normal spikes in amplitude. Body movement, eye blinking and jaw movements can cause interference with the signal recording. In this study, participants were singing and playing drums which required movement. In some cases HR and RR could not be obtained because of technical interference. This is perhaps the most significant limitation of this study, which will be explored further in the discussion of the results.

Due to the design of the study, with its lack of randomisation, control and a large enough sample, as well as its various other limitations discussed so far, results cannot be generalised to the wider population of older adults and persons with dementia. This is partly due to feasibility issues of being a Master's thesis project. However, the nature of the study was exploratory and therefore did not yet warrant a large-scale study. The current study acted as a pilot study that could inform the design of future research based on the challenges and learnings that were found. This groundwork may then motivate for a larger-scale and more robust study that can provide generalisable results and explanation of causation.

Chapter 4: Analysis and Results

4.1 Introduction

This chapter will present the results from the statistical analysis of the neurophysiological data. The three parameters HR, RR, and EEG, will be presented separately. Descriptive and comparative statistics will serve to answer the following research questions:

- What are the neurophysiological responses to music therapy components in participants with and without dementia?
- To what extent does the severity of dementia mediate neurophysiological activity during exposure to music therapy components?
- To what extent do results differ between the individual components of the music therapy intervention?

4.2 Sample Demographics

Table 4 outlines the sample demographics including information on age, sex, and diagnoses. Group A consisted of five participants with no symptoms of dementia (4 female and 1 male aged 68–78 years, *M* 73 years, *SD* 4.4). Group B consisted of eight participants with mild to moderate dementia (7 female and 1 male aged 75–91 years, *M* 82.1 years, *SD* 4.8) and group C consisted of five participants with severe dementia (4 female and 1 male aged 69–92 years, *M* 81.6 years, *SD* 8.9). Participants in group A provided their own personal information. Information for participants in groups B and C were obtained from their medical files kept at the facility. For medication information and dementia severity rating see Appendix G.

[Table 4 Follows]

Table 4: Sample demographics

Participant	Sex	Age (years)	Diagnoses
A1	F	72	None
A2	F	78	Hypertension
A3	F	68	Hypertension
A4	M	70	None
A5	F	77	Hypertension
	M* = 73 years *(SD = 4.4)		
B1	F	84	Hypertension, Depression
B2	F	75	Hypertension, depression,
B3	F	85	Hypertension
B4	M	82	Hypertension, Cancer (prostate)
B5	F	81	None
B6	F	91	Hypertension, Depression
B7	F	78	Thyroid condition (unspecified), Diabetes type 2
B8	F	81	Hypertension, Osteoporosis
	***M* = 82.1 years (*SD* = 4.8)**		
C1	F	79	Hypertension, Diabetes (type 2), Alzheimer's Disease
C2	F	69	Diabetes (type 1), Asthma, Alzheimer's Disease
C3	F	80	Diabetes (type 1), Vascular Dementia
C4	F	88	Dementia (unspecified)
C5	M	92	Hypertension, Dementia (unspecified)
	***M* = 81.6 years (*SD* = 8.9)**		
Total Sample *M* = 79.4 years (*SD* = 7)			

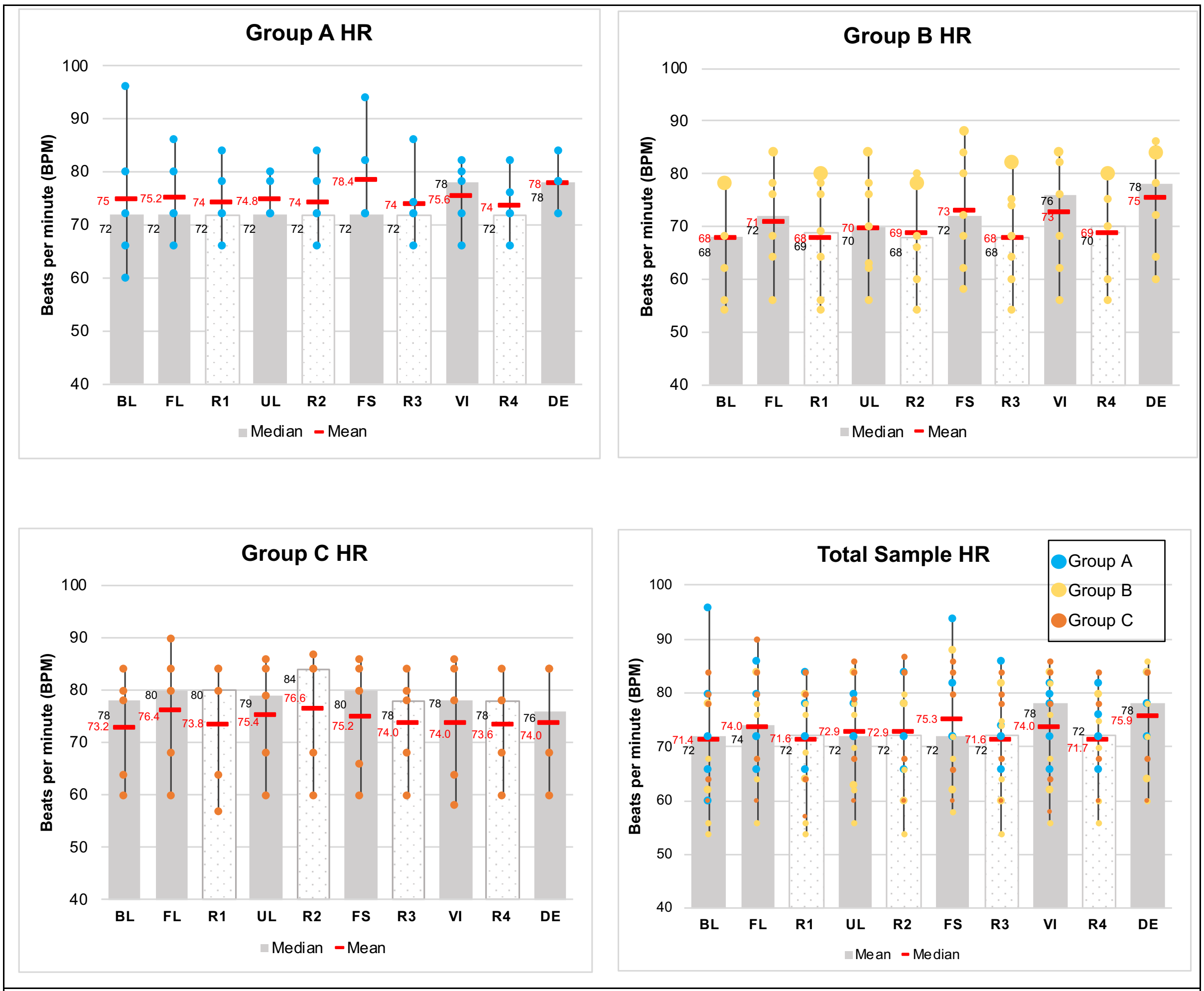
4.3 Heart Rate

Table 5 presents the descriptive statistics for the HR measure for each component including baseline. The values are given in beats per minute (BPM). The mean, median, standard deviation and interquartile range are given for each group. The mean is included though it should be noted that in the comparative analysis, due to the use of non-parametric tests, it is the median rather than the mean that is used. HR data was missing for some participants during certain components. No HR data was obtained for participant B8 throughout the session. Participant B2 had no RR for the FL component and C4 had no RR for the DE component.

Table 5: HR Descriptive Statistics

	Heart Rate (BPM)			
	M	*Mdn*	*SD*	*IQR*
Baseline				
A	74.80	72	13.97	25
B	67.71	68	10.61	22
C	73.20	78	10.54	20
Total	71.41	72	11.38	18
Familiar Listening (FL)				
A	75.20	72	7.82	14
B	71	72	10.26	18
C	76.4	80	12.2	23
Total	74	74	9.85	17
Unfamiliar Listening (UL)				
A	74.80	72	3.9	7
B	69.86	70	10.04	16
C	75.40	79	11.08	21
Total	72.94	72	8.91	14
Familiar Singing (FS)				
A	78.40	72	9.74	16
B	73.14	72	11.31	22
C	75.20	80	11.54	22
Total	75.29	72	10.49	17
Vocal Improvisation (VI)				
A	75.60	78	6.54	12
B	72.86	76	11.01	20
C	74	78	12.41	24
Total	74	78	9.8	17
Drumming Exercise (DE)				
A	78	78	4.24	6
B	75.43	78	10.37	20
C	74	76	12	22
Total	75.88	78	8.9	15

HR varied across the sample and within the groups. It appears that HR returned to baseline levels in most of the resting periods for the total sample and groups A and B, as illustrated in Figure 5. However, group C showed an increase in median HR for resting period 1 and in both median and mean HR for resting period 2.



BL= Baseline, FL=Familiar Listening, R1 = Rest 1, UL = Unfamiliar Listening, R2 = Rest 2, FS = Familiar Singing, R3 = Rest 3, VI = Vocal Improvisation, R4 = Rest 4, DE = Drumming Exercise

Figure 5: HR for groups A-C and total sample

In general, group C had higher median HR for most of the components except for the DE. However, when using the mean it appears that group A and C are not very different. This can be seen more clearly in Figure 6.

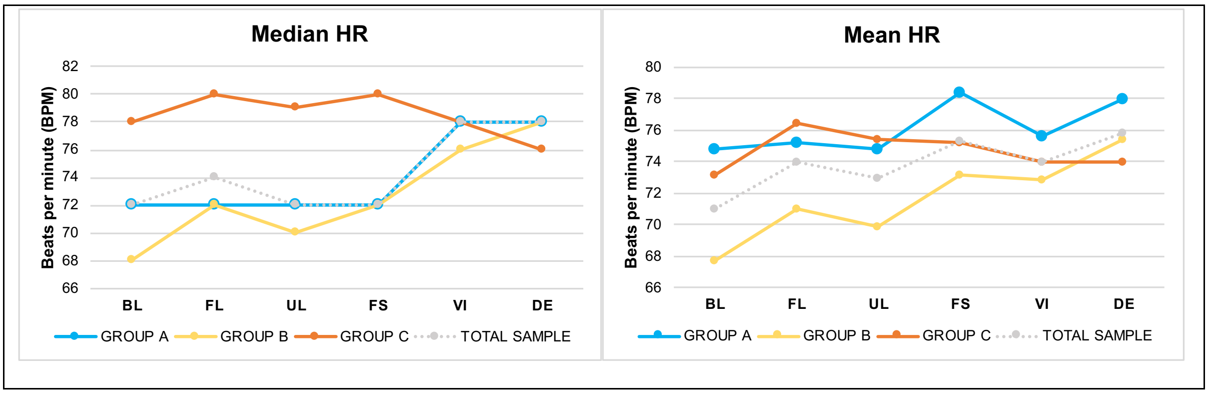


Figure 6: Line graph showing change in HR across session

Group A showed an increase in median HR for the VI and DE components, and mean HR for all of the active components (i.e. FS, VI and DE). Group B showed a general increase from baseline in both median and mean HR with greatest increases in mean HR for the active components. Group C did not follow this trend. Median and mean HR was slightly higher for FL, UL and FS. Median HR remained the same as baseline for VI and decreased for DE. Using the mean, VI and DE were very slightly higher than baseline. For the total sample, there was a slight increase in median HR for the FL and a larger increase for VI and DE. Using the mean shows that HR increased for all components, most notably the FS and DE components.

4.3.1 Comparison of Groups

Groups A, B and C were compared for each component using an Independent-Samples Kruskal-Wallis Test. The significance level (*p*) was set to 0.05. Table 6 summarises the results, showing that no statistically significant results were found. This indicates that, although differences were observed in the descriptive statistics, this may be due to chance. This may also be due to the high level of variability and 'skewness' of the data for groups A and C.

Table 6: Statistical comparison of group differences in HR

Session Component	***p***
Baseline	0.47
Familiar Listening	0.607
Unfamiliar Listening	0.492
Familiar Singing	0.75
Vocal Improvisation	0.931
Drumming Exercise	0.951
Significance level set to *p*=0.05	

4.3.2 Comparison of Components

In order to compare the HR between components a Related-Samples Friedman's Two-Way Analysis of Variance by Ranks was used. The results are summarised in Table 7. Significant results, falling below the significance level of 0.05, are highlighted in green. Significant differences were found for the total sample (i.e. across groups) and for group B. Table 8 shows the pairwise comparison for the significant results to determine where the differences lie within the session components. The adjusted significance is used. Significant differences were found for the total sample for the FS and DE components when compared to baseline. When analysing group B the results for the same components were no longer significant when adjusted (highlighted in yellow), however they are very close to 0.05. This suggests that the differences across the sample are likely attributed mostly to Group B participants.

Table 7: Statistical comparison of component differences in HR

Group	*p*
A	0.579
B	0.004
C	0.077
Total Sample	0.002

Table 8: Pairwise comparison of components for total sample and group B

Group	Pair	Significance	Adjusted significance*
Total Sample	Baseline-FS	.003	.044
	Baseline-DE	.001	.019
B	Baseline-FS	.004	.065
	Baseline-DE	.003	.051

*Significance values have been adjusted by the Bonferroni correction for multiple tests.

Group B showed an increase in median and mean HR from baseline (*Mdn*=68BPM, *M*=68BPM) for the FS (*Mdn*=72BPM, *M*=73BPM) and DE (*Mdn*=78BPM, *M*=75.4BPM) components. The vocal improvisation component also showed an increase (*Mdn*=76, *M*=72.9) but this was not found to be statistically significant. However, this could possibly indicate that the active music therapy components overall induced an increase in HR.

4.3.3 Summary of Heart Rate Results

The statistical analysis of the HR data revealed a small number of significant results. When comparing group differences for each component it was found that no differences were significant, indicating that dementia was unlikely to play a mediating role in the cardiovascular response to any components. However, when comparing the components a significant change from baseline was found for the FS and DE components. This was clearest in Group B (mild-moderate dementia) where HR generally increased from baseline and preceding resting periods. Although the change from baseline and resting for the VI component appeared similar to FS and DE but was not statistically significant, it perhaps contributes to a hypothesis of active music therapy components inducing an increase in HR. According to the descriptive statistics, this trend was not as clear in Group C.

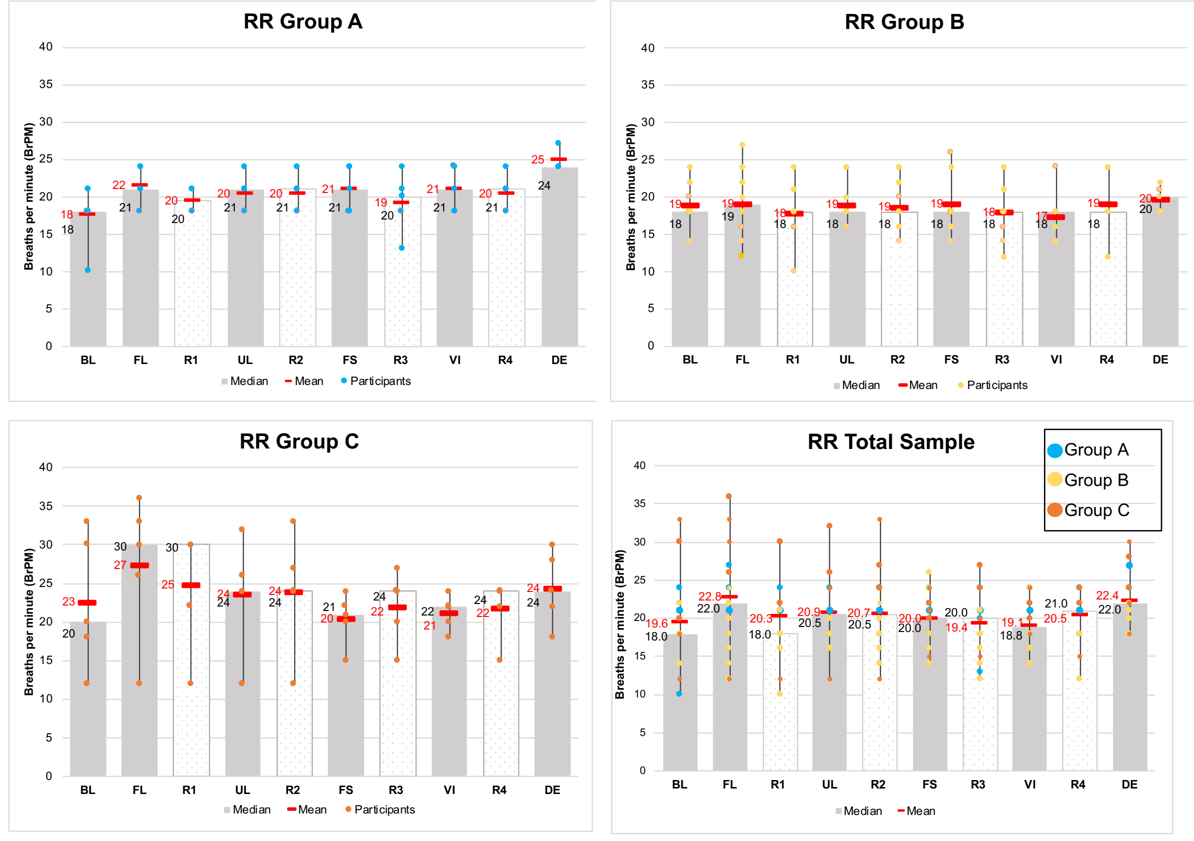
4.4 Respiration Rate

RR data will be presented in the same way as HR. Table 9 presents the descriptive statistics for the HR measures for each component including baseline. The values are reported in breaths per minute (BrPM). RR was not always obtainable for all participants as a result of signal interference. For the FS and VI components participant B3 had no RR value and in the DE component participants A1, A3, B1, B2 and B3 had no RR.

Table 9: Respiration Rate descriptive statistics

	Respiration Rate (BrPM)			
	M	*Mdn*	*SD*	*IQR*
Baseline				
A	17.6	18	4.51	7
B	19	18	3.02	4
C	22.6	20	8.71	17
Total	19.61	18	5.51	3
Familiar Listening (FL)				
A	21.6	21	2.51	5
B	19.13	19	5.11	9
C	27.4	30	9.37	16
Total	22.11	21.5	6.74	9
Unfamiliar Listening (UL)				
A	20.4	21	2.51	5
B	19	18	3.38	7
C	23.6	24	7.27	11
Total	20.67	20.5	4.74	7
Familiar Singing (FS)				
A	21	21	3	6
B	18.13	18	4.91	8
C	20.4	21	3.36	6
Total	20.06	20	4.06	7
Vocal Improvisation (VI)				
A	21	21	3	6
B	16.63	17	3.89	4
C	21.2	22	2.28	4
Total	19.59	18	3.85	5
Drumming Exercise (DE)				
A	25	24	1.73	3
B	19.8	20	1.79	4
C	24.4	24	4.78	9
Total	22.77	22	3.9	7

Across the total sample RR appeared to be highly varied in the receptive components (FL *SD*=6.7BrPM and UL *SD*=4.7BrPM) but more centred around the median and mean in the active components (FS SD=4.1, VI *SD*=3.9, and DE SD=3.9) where the values are less spread out. Group C appeared to vary more extremely than groups A and B. These differences can be seen more clearly in Figure 7. It should be mentioned that participant C2 was a possible outlier for FL and FS, and a probable outlier for UL. Participant C4 was also a probable outlier for the UL component.



BL = Baseline, FL=Familiar Listening, R1 = Rest 1, UL = Unfamiliar Listening, R2 = Rest 2,
FS = Familiar Singing, R3 = Rest 3, VI = Vocal Improvisation, R4 = Rest 4, DE = Drumming Exercise

Figure 7: RR for groups A–C and total sample

Several differences between groups and components can be observed. Group B appeared to generally have lower RR than groups A and C. Group A showed an increase from baseline for all components with the largest increase for the DE. Group B also had the largest increase in RR for the DE whereas group C had highest RR in FL. Groups B and C had lowest RR in the singing components (FS and VI). RR for the total sample appeared to increase for all components except for the VI.

4.4.1 Comparison of Groups

Groups were again compared for each component using an Independent-Samples Kruskal-Wallis Test. The significance level (*p*) was set to 0.05. Table 10 presents the results with statistically significant results highlighted in green. Values between 0.05 and 0.1 are highlighted in yellow to show results that were close to significance had the significance level been adjusted to 0.1.

Table 10: Comparison of groups A–C RR for each component using Kruskal-Wallis test

Session Component	*p*
Baseline	0.693
Familiar Listening	0.136
Unfamiliar Listening	0.192
Familiar Singing	0.415
Vocal Improvisation	0.048
Drumming Exercise	0.066
Significance level set to p=0.05	

When comparing groups for each component, the only statistically significant result occurred during the VI (*p*=0.048). Table 11 shows the pairwise comparisons performed to identify between which groups the significant difference occurred. Group B's median and mean RR (*Mdn*=16.6 BrPM, *M*=17 BrPM) were lower than group A (*Mdn*=21, *M*=21) and C (*Mdn*=21.2, *M*=22), however when the significance was adjusted to account for multiple tests of significance on the same data, it appears that these differences were not significant. This could mean that the difference was distributed across the sample rather than concentrated in one group.

Table 11: Pairwise comparison of groups RR in VI

Group comparison	Significance	Adjusted Sig.*
B - A	0.048	0.143
B - C	0.035	0.104
A - C	0.903	1
*Significance values have been adjusted by the Bonferroni correction for multiple tests.		

4.4.2 Comparison of Components

The comparison of components was completed in the same way as the HR analysis. The results are summarised in Table 12. There were no statistically significant differences between the components. The *p*-value for the total sample (*p*=0.91) was highlighted as it is close to being significant, if the significance level were adjusted. This suggests there is a possible difference between components for the total sample but statistically locating those differences is not possible without adjusting the significance.

Table 12: Friedman comparison of RR across components

Group	*p*
A	0.186
B	0.425
C	0.320
Total Sample	0.91
Significance level was set to *p*=0.05	

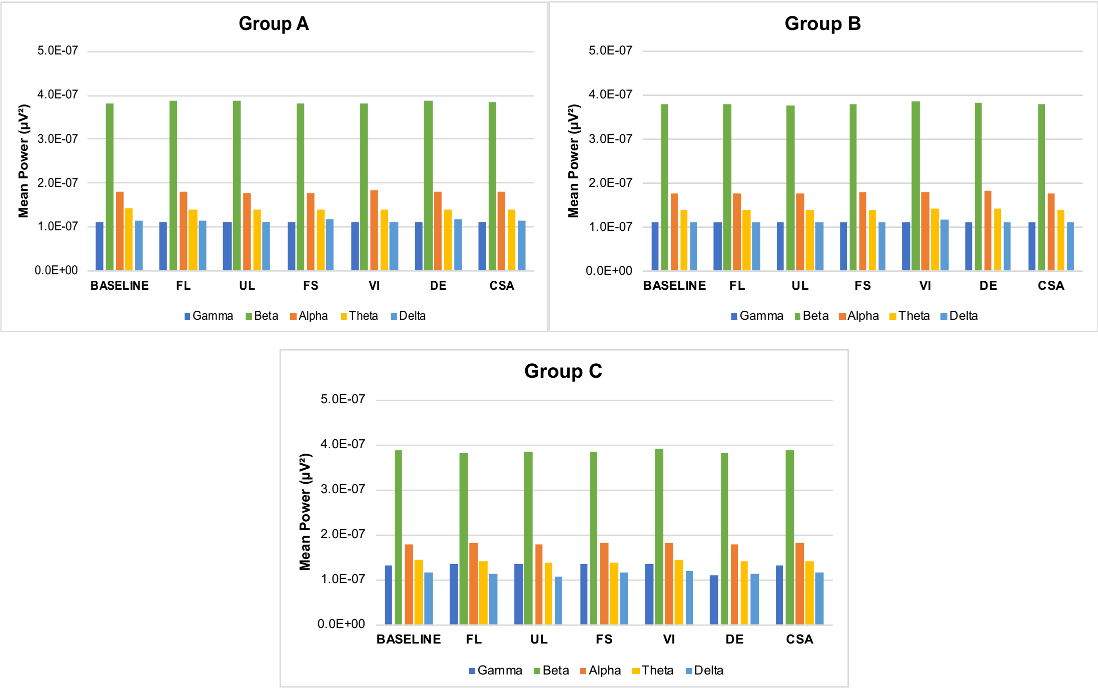
4.4.3 Summary of Respiration Rate Results

The statistical analysis of the RR data revealed few significant results. Whilst differences can be seen when comparing the descriptive statistics, such as an increase for DE, these did not reflect in the non-parametric tests. The only significant result was between groups in the VI component, however the specific group differences could not be found when adjusted for multiple tests of significance. This indicates that dementia likely played no mediating role in the respiration activity during the music therapy components. It also indicates that the type of music therapy component did not significantly affect respiration rate. The data was highly variable, with a number of participants within the already small groups appearing as possible and probable outliers, which may have affected the outcomes. Further investigation of real-time activity will be presented in chapter 5.

4.5 EEG

Descriptive statistics will be presented in graph format as the combination of multiple components, groups and frequency bands produces an overwhelming volume of data. For the full set of descriptive statistics in tabular form see Appendix H. Comparative statistics will be presented in the same format as the HR and RR data.

The distribution of the five frequency bands was consistent for all components across all groups. Figure 8 presents the median absolute power for each frequency band and component for groups A–C. For all groups and components Beta power appears to be 3 times higher than Gamma and Delta, and two times higher than Alpha and Theta. Beta is generally found to be the dominant frequency in eyes-open wakeful and alert states.



FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise, CSA = Complete Session Average

Figure 8: EEG distribution of frequency bands for groups A–C

4.5.1 Comparison of Groups

There appear to be no immediately observable differences between groups or components, however statistical comparison reveals a number of significant results.

Table 13 presents the comparison of the three groups. Significant differences were present in the Gamma band for UL, FL and the overall session average, the Beta band for baseline, and Theta for FL. Delta had two results of possible significance but these were not statistically investigated further.

[Table 13 follows]

Table 13: EEG comparison of Groups A–C using Kruskal-Wallis Test

	(p)				
	Gamma	**Beta**	**Alpha**	**Theta**	**Delta**
Baseline	0.089	0.041	0.147	0.174	0.564
FL	0.15	0.409	0.311	0.027	0.984
UL	0.044	0.364	0.334	0.965	0.759
FS	0.022	0.128	0.358	0.189	0.098
VI	0.15	0.584	0.554	0.616	0.216
DE	0.743	0.698	0.774	0.743	0.158
CSA	0.006	0.261	0.229	0.079	0.058

FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise, CSA = Complete Session Average

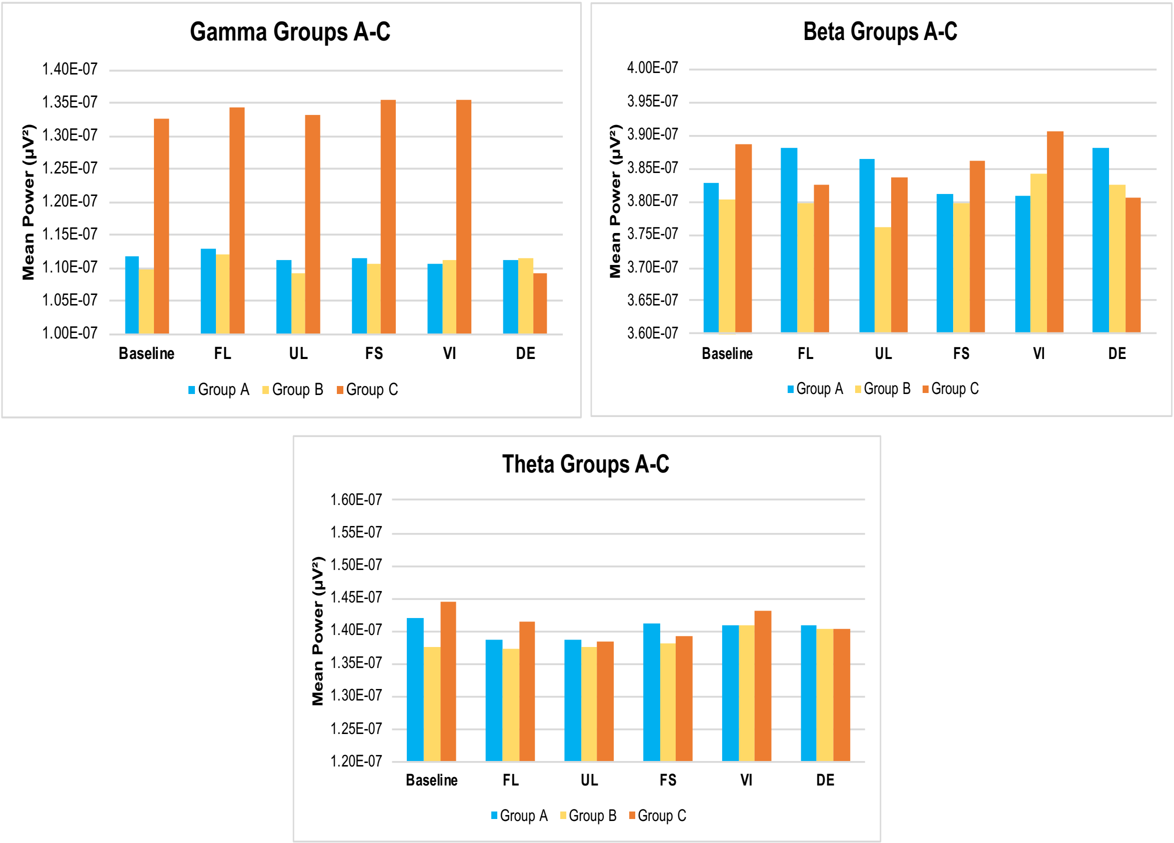
All significant differences were between Group B and Group C (Table 14). Gamma differed between the two groups for the two listening components as well as the complete session average. Beta differed between these groups for baseline, and Theta for the FL component.

Table 14: EEG pairwise comparison of significant results

Frequency Band	Component	Group Pair	Significance (*p*)	adj sig*
Gamma	UL	B – C	0.013	0.04
	FS	B – C	0.007	0.02
	CSA	B – C	0.002	0.006
		A – C	0.017	0.052
Beta	Baseline	B – C	0.012	0.036
Theta	FL	B – C	0.009	0.026

*Significance values have been adjusted by the Bonferroni correction for multiple tests.

Figure 9 shows the distributions between groups for the three frequency bands of significance. Group C's median Gamma power was consistently higher in these significant cases and in general. However, in the DE Group C's Gamma power was lower than the other two groups. Although the groups were not statistically significantly different for the baseline measure (*p*=0.089), this trend was visibly present in the baseline. This suggests that the groups had different levels of Gamma power, albeit very minimal, to begin with. The significant results found for Beta during baseline and Theta during FL followed a similar distribution (i.e. highest in group C). However, for Beta this distribution was not consistent throughout the session and for Theta the difference between groups was extremely small.



FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise

Figure 9: EEG Gamma, Beta and Theta power for groups A–C

4.5.2 Comparison of Components

The five music therapy components, baseline measure and complete session average were compared using Related-Samples Friedman's Two-Way Analysis of Variance by Ranks. Table 15 summarises the outcomes both when baseline was included in the distribution as well as when the complete session average was used. No significant differences were found when using baseline, however some were found when using the CSA.

[Table 15 follows]

Table 15: EEG comparison of components using Friedman's test

Comparison of components including BL measure (*p*)					
	Gamma	**Beta**	**Alpha**	**Theta**	**Delta**
Group A	0.891	0.99	0.829	0.124	0.375
Group B	0.328	0.787	0.138	0.059	0.787
Group C	0.1	0.587	0.829	0.953	0.43
Total sample	0.563	0.973	0.217	0.063	0.727
Comparison of components including Complete Session Average (*p*)					
	Gamma	**Beta**	**Alpha**	**Theta**	**Delta**
Group A	0.891	0.971	0.779	0.048	0.402
Group B	0.221	0.421	0.092	0.032	0.858
Group C	0.048	0.796	0.537	0.796	0.234
Total sample	0.38	0.641	0.091	0.006	0.713

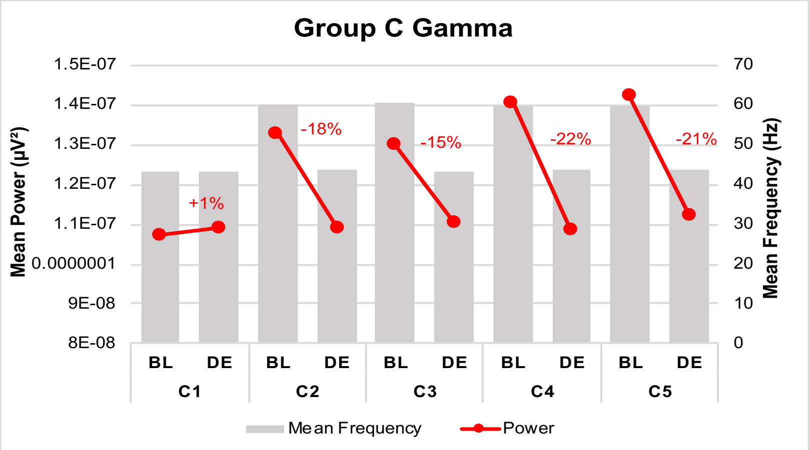
A pairwise comparison (Table 16) showed that the difference for Gamma in Group C was between the DE and the FS components. Median Gamma power was 19% lower for DE than for FS (see Figure 9). Gamma power decreased by 18% from Baseline. It also appears to be lower than the other components but this was not found to be statistically significant.

Table 16: EEG pairwise comparison of significant results using Friedman's test

	Group	**Pair**	**Significance (*p*)**	**Adjusted significance***
Gamma	C	**DE – FS**	**0.001**	**0.02**
Theta	Total	FL – CSA	0.035	0.525
		FL – DE	0.017	0.257
		FL – VI	**0.001**	**0.014**
		UL – DE	0.035	0.525
		UL – VI	**0.002**	**0.037**
	A	FL – FS	0.043	0.638
		FL – DE	0.043	0.638
		FL – VI	**0.002**	**0.035**
		UL – VI	0.028	0.420
	B	FL – CSA	0.032	0.482
		FL – DE	0.007	0.100
		FL – VI	0.007	0.100
		UL – DE	0.046	0.683
		UL – VI	0.046	0.683

FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing,
VI = Vocal Improvisation, DE = Drumming Exercise

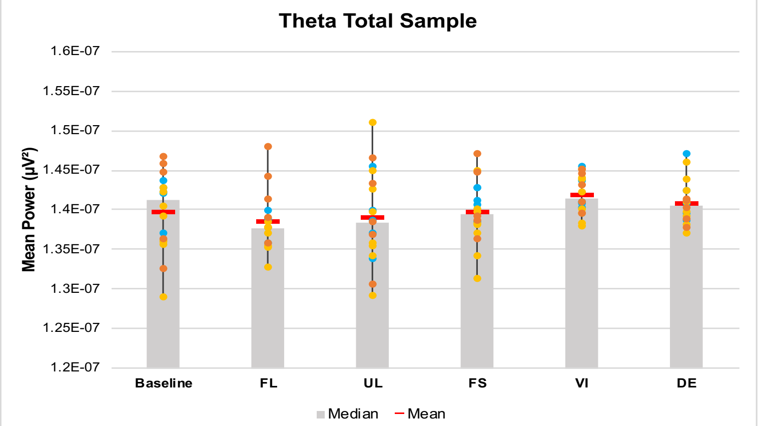
The decrease in Gamma power for the DE component was attributed to four of the five group C participants (Figure 10). Mean power and mean frequency were elevated for baseline, FL, UL, FS, and VI components but reduced during the DE by 15–22%. This trend was not seen in participant C1 or any other participants in groups A or B.



BL = Baseline, DE = Drumming Exercise, C1–5 = Participants C1–5

Figure 10: Gamma power and frequency changes from baseline to DE Group C

Statistically significant differences for the Theta band were found for the total sample between both listening components (FL and UL) compared to VI (Figure 11). Median Theta power during the VI was 2% higher than FL and 1.5% higher than UL. A second significant difference was found between the FL and VI components in group A where median Theta power was higher for VI (see Figure 9). In both of these cases, whilst differences can be seen graphically, they are very narrow.



FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise

Figure 11: EEG Theta power for total sample

The potential significant differences in the Alpha band for the total sample (*p*=0.091) and group B (*p*=0.092) are likely attributed to changes during the DE where Alpha power increased by 3%.

4.5.3 Summary of EEG Results

Overall there was very minimal change (<5%) for the components across the frequency bands and groups. Whilst statistically significant differences in Theta power were found for the total sample when comparing FL and VI, they were very narrow changes. The only statistically significant and notable difference was the large (19%) decrease from the FS for Gamma power in group C during the DE component as well as a decrease (18%) from baseline.

4.6 Conclusion

This chapter has presented the results of the statistical analysis. Neurophysiological responses appeared to differ amongst the three parameters. The HR data showed a statistically significant increase in HR for the FS and DE components. In addition, VI followed the same increase trend, and whilst not statistically significant, this suggests that active components generally increased HR. Whilst differences were observed in the RR using descriptive statistics, such as an increase during the DE for groups A and B, during the FL for group C, and singing components generally remaining very similar to baseline levels, there was minimal statistical significance. The EEG data showed a clear dominance of Beta power throughout components and groups when comparing the frequency bands. Group C appeared to have generally higher Gamma power than groups A and B. The most notable difference was a significant decrease in Gamma power for group C during the DE component. The statistical significances for the Theta band were practically very narrow. These findings will be discussed in relation to the research questions in the following chapter.

Chapter 5: Discussion

5.1 Introduction

This study aimed to explore the neurophysiological activity that occurs during music therapy with individuals with and without dementia. It sought to investigate the potential mediating role that dementia severity played in these responses as well as how responses differed according to the type of music therapy technique that was used. This chapter will firstly offer a discussion of the results from the statistical analysis of the neurophysiological data in relation to the research questions and the broader literature. Secondly an exploration of four case examples will be presented in order to illustrate a number of significant moments and individual neurophysiological responses. A discussion of the specific limitations of this research will follow, ending with a reflection on experimental music therapy research.

5.2 Neurophysiological Activity

This section will explore the results from each of the three parameters separately as each offered its own insight into the research questions. The heart rate (HR) data showed a modest difference between receptive and active techniques. The respiration rate (RR) data lacked statistical significance but a descriptive analysis revealed that singing influenced RR greatly and that the FL and DE components increased RR modestly. The EEG data offered limited findings, however there were some interesting changes in the Gamma and Theta bands. There were limited findings regarding group differences, indicating that the severity of dementia played a minimal role, if any. Therefore the focus of the discussion is on older adults and persons with varying severity of dementia in general. It should be mentioned once more that because of the limitations of this study, namely the lack of control conditions and also the technical difficulties encountered, discussion of the results, both statistically significant and nonsignificant, is explorative and speculative.

5.2.1 Heart Rate

The statistical analysis of the HR data revealed a small number of significant results. When comparing group differences for each component it was found that no differences were significant, suggesting that dementia was unlikely to play a mediating role in the cardiovascular response to any components. However, HR varied throughout the session with a trend towards increased HR during the active music therapy components. FS, VI and DE represented active music therapy techniques where the client is engaged in music-making. Whilst the research on the cardiovascular responses to active-music making is limited, there is some evidence that music performance increases heart rate more than music listening

(Nakahara et al., 2011). This could be due to the rewarding and enjoyable experience of music-making, potential performance anxiety and/or the physical activity involved.

Music-making is often an enjoyable experience associated with positive emotions. Singing, for example, is frequently shown to be an enjoyable activity for older adults and persons with dementia, particularly in group settings (Cho, 2018; Dassa & Amir, 2014; Hara, 2011; Lesta & Petocz, 2006; S. Li & Southcott, 2012; Ridder, 2003). Experiencing happiness has been shown to mildly increase (+2BPM) HR (Ekman et al., 1983). Experiencing emotional excitement increases HR more significantly (+6–8BPM) (Piira et al., 2013). Therefore the possible increase in pleasant emotions may have contributed to the increases in HR during the FS and DE components.

Music of personal significance can evoke strong emotions and memories. Whilst music may evoke both pleasant and difficult memories, familiar music tends to evoke mostly positive emotional memories (Cuddy et al., 2017; El Haj et al., 2012). The FS component used songs that were familiar to the participants. Therefore, the familiarity of the music may have induced emotion. Interestingly, for persons with AD even when there is no explicit recall of the related memory or event, they may still reexperience the associated feelings (Guzmán-Vélez et al., 2014). Music with stronger emotional arousal has been shown to increase HR more significant than less emotionally arousing music (Iwanaga & Tsukamoto, 1997; Lynar et al., 2017; Nakahara et al., 2011). Therefore, the addition of familiarity to the active music-making may have contributed to an increase in emotional arousal and a resulting increase in HR, beyond the level of the FL component.

Whilst singing can be enjoyable, for some people it may induce a stress response because of the performance element. During performances, musicians show increases in HR and blood pressure (Spahn et al., 2010). In the sessions, several participants were hesitant to sing, some expressing that they do not have “a good singing voice” (e.g. participant C3), or improvise, saying they are not “creative” (e.g. participant B2). Clients may feel uncomfortable when first being asked to use their voice as it may evoke feelings of being exposed (Wigram et al., 2002). Hesitation was much more evident in the VI component across the groups. This may be because of uncertainty with what the task involved due to inexperience with improvisation or discomfort associated with spontaneous music creation. Participant C1 who presented with disinhibited behaviour, however, demonstrated no hesitation throughout the session. In stressful situations the SNS is activated, hormones such as cortisol and adrenaline are released and cardiovascular activity accelerates. However, activation of the SNS does not indicate the condition is ‘stressful’ or unpleasant, it can simply indicate preparation for physical activity. It should also be noted that the physiological markers of anxiety and excitement are similar – both characterised by higher arousal and increased HR (Brooks, 2014; J. C. Smith et al., 2005).

Active music therapy techniques are more cognitively demanding than receptive techniques. Increased cognitive demand has been associated with increases in HR (Vanden Noven et al., 2014). In order to play an instrument or sing, multiple mental processes are involved, such as tracking the pulse, differentiating auditory feedback, the anticipation of rhythm, pitch and lyrics, motor control and planning in order to execute the required movements (McPherson et al., 2019). The FS, VI and DE all increased cognitive demand, which may have contributed to increases in HR. There is evidence of not only preserved recognition of music in persons with late-stage dementia but also preserved musical ability (Baird & Thompson, 2020). Music-making may therefore be of particular benefit for persons with dementia, as it is an accessible and enjoyable form of cognitive stimulation.

Active music-making techniques are also more physically demanding than receptive techniques where clients are typically still. HR fluctuates more during motor responses than in perceptual discrimination (Lacey & Lacey, 1974). The DE is unique amongst the components as it involved constant physical activity. Drumming is considered low-moderate exercise, therefore the increase in HR could likely be attributed to this increased physical activity (C. Smith et al., 2014). The results of this study, therefore, support those found by C. Smith et al. (2014), where HR increased in older adults during drumming. Low-moderate exercise is recommended for older adults, especially those with hypertension, as it can improve blood pressure and cardiovascular health without the risk of adverse reactions associated with higher intensity exercise (Pescatello, 2005). Because of the contribution of cardiovascular diseases to the development of dementia, improving cardiovascular health through exercise can reduce the risk of dementia (Ahlskog et al., 2011). For persons with dementia regular exercise programming has shown improvements in cognitive functioning (Ahlskog et al., 2011). Therefore, drumming may be a useful approach to improving not only psychological and social wellbeing but also physical wellbeing. Further research into the potential neuroprotective effects of drumming would be beneficial.

The active components were not only different because of the musical performance element, but also because of the level of interaction. The social element of active music-making may have been an influencing factor. Whilst this could have been controlled for by isolating participants (see Bernardi et al., 2017), interaction and connection between client and therapist are at the core of music therapy practice. Sakamoto et al. (2013) investigated the social element of music therapy and found that participants in the interactive music therapy condition showed a decrease in HR and an increase in PNS activity. However, this was measured after, not during the session. This does not contradict the findings of the current study as it is possible that HR may increase during music-making but decrease after, as seen in participant B5 (case example is discussed further in section 5.3.4).

The discussion of HR thus far has focused on active techniques. Whilst the changes in HR during the FL component were not statistically significant, group B and C showed a marked increase in HR from baseline. However, for many participants in these groups the component involved physical movement and verbal interaction between participant and therapist. Therefore this became more of an ‘active’ experience for some. Whilst the original intention may not be to incorporate movement, clients may still listen and respond actively.

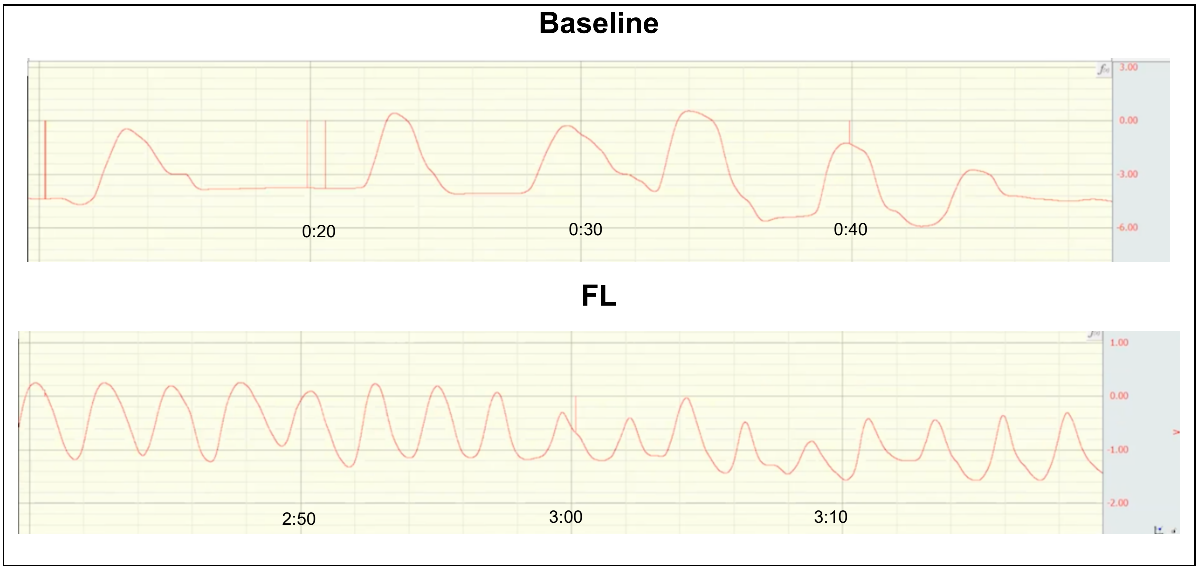
Several studies have demonstrated lower HR during slow sedative music when compared to faster stimulating music (Etzel et al., 2006; Lingham & Theorell, 2009). In this study, there are both contradictory and confirming results in relation to this trend. Group A showed little to no difference between the FL (fast and exciting) and UL (slow and sedative) components. However, groups B and C showed a slight increase during the UL, although less than the increase during FL, which supports Lingham and Theorell's (2009) similar findings. Perhaps dementia played a mediating role in this, possibly indicating that persons with dementia were more reactive to music as a stimulus in general.

To conclude this section, it should be restated that it is not possible to draw definite psychophysiological conclusions from a simple measure such as HR. Whilst an increase in HR may indicate sympathetic activation it could also reflect a decrease in parasympathetic activity or even both (Berntson et al., 2007). It is recommended to use multiple physiological parameters in order to provide more context. The RR data, which will be discussed in the following section, offers some further insight.

5.2.2 Respiration

RR fluctuated varied between the components but group differences were minimal. Statistical analysis and exploration of the descriptive data, suggests that it is unlikely that the severity of dementia played a mediating role in RR. Whilst statistical analysis suggests that components did not differ, exploration of the descriptive data reveals a number of trends. Firstly, during music listening, the two pieces had different responses, suggesting that the different characteristics of the music influenced respiratory responses. Secondly, RR during the singing components was determined by the singing style and musical structure. Finally, a clear increase during the DE component reflects increased physical activity and physiological arousal.

Qualities and characteristics of the pieces of music used in the listening components may have influenced RR. Whilst variations in RR were not found to be statistically significant (*p*=0.091), there were observable trends and clear changes for individual participants. The increase during the FL component may have been tempo-, movement- or emotion-related. Faster tempos have been linked to shorter breaths and faster breathing cycles (Etzel et al., 2006). The song seemed to induce movement for many participants. Whilst often the movement was subtle and they remained seated, this increase in physical activity may reflect similarities with aerobic exercise, which typically increases RR (Lorig, 2007). The song was familiar to the era of the participants' youth and therefore may have evoked emotion and possible excitement. Increases in RR have been associated with listening to preferred music (O'Kelly et al., 2013), music categorised as 'happy' (Krumhansl, 1997), and having pleasurable responses to music (Blood & Zatorre, 2001). Participant A1 is an example of this change in respiration pattern and the related behaviours (Figure 12).


Baseline

FL

Figure 12: Participant A1 RR changes from Baseline to FL

The piece used in the UL component was slow and lyrical. These characteristics have been associated with decreased RR as they can induce states of relaxation (Etzel et al., 2006; Iwanaga et al., 2005). Participants were generally very still, some closing their eyes, indicating that they were possibly relaxed. However, changes in RR were mixed across the sample. Some showed a decrease, whilst others remained the same or even increased. The literature also reveals mixed conclusion. Even though the music was generally 'sedative', it also had moments of change, increasing intensity and climax. The increase for some participants could therefore be attributed to attentive listening (Brown, 1962) and emotional arousal (Blood & Zatorre, 2001). A1 showed a change in respiratory pattern in different parts of the piece. For example, Figure 13 shows the change from shallow breathing to a sudden increase in respiratory volume that coincides with the musical climax and release. This response, however, was not found for all participants.

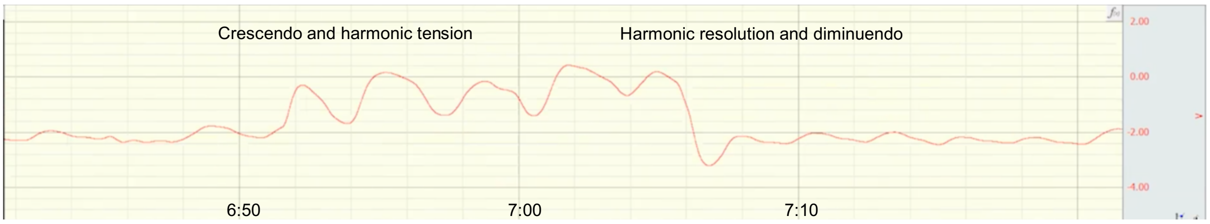


Figure 13: Participant A1 respiration during UL

It was clear that singing highly affected RR. Singing interrupts normal breathing patterns, requiring the person to control their breath, slow their exhalation and deepen their inspiration in order to sing the musical phrases (Bernardi et al., 2017). RR depended on the musical phrasing and the participant's breath control ability. Despite singing the same songs throughout the group, breathing pattern varied greatly. In previous studies, this has been controlled for by giving participants breathing instructions (Bernardi et al., 2017; Vickhoff et al., 2013).

The FS component provided regular and predictable musical structure. However, not all participants breathed in the same pattern. Figure 14 shows an example of taking more frequent breaths than the more 'standard' breath placement. Had they breathed after every two bars (6 beats), perhaps the more musically 'expect' breathing pattern, her RR would have halved (13BrPM vs 26BrPM). This may possibly be due to reduced lung capacity, which is common in the elderly (Johnson, 2014; Lorig, 2007). Some participants sang longer phrases per breath (Figure 15). This, therefore, makes interpreting RR from a psychophysiological perspective during singing inappropriate as it is likely the musical structure and participant breath control that is responsible.

[Figure 14 follows]

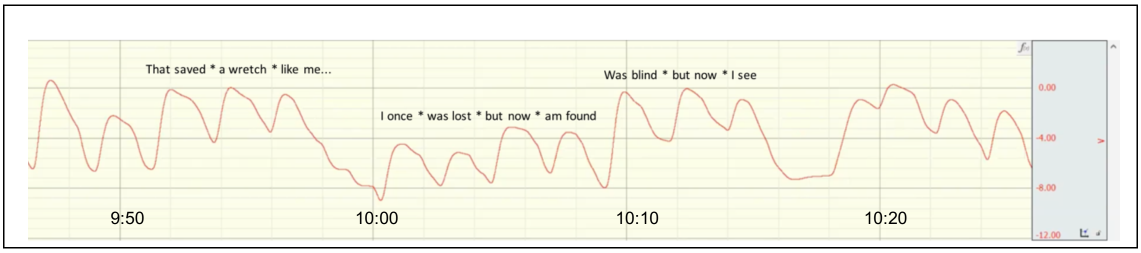


Figure 14: Participant B6 Respiration during FS

Figure 15: Participant A3 Respiration during FS

The VI component had a less predictable structure and therefore more varied respiration patterns. Furthermore, many participants were silent for long periods as they were hesitant to join in with the improvisation, whereas some sang throughout. For example, participant B7 sang throughout, following the musical structure and their pattern of breath control shows slower deeper breaths (Figure 16). Their RR showed a decrease from baseline (-2 BrPM).

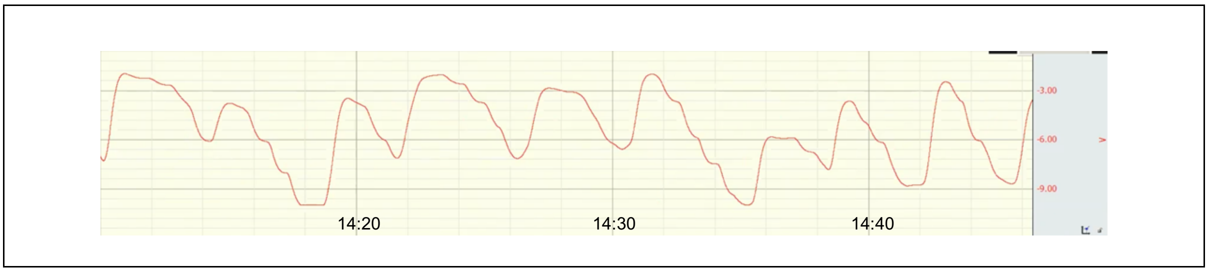


Figure 16: Participant B7 Respiration during VI

Participant B6, however, showed an increase from BL. There were periods of silence with short shallow breathing, singing long phrases (Figure 17) but also singing much shorter phrases. Therefore, the unpredictable musical structure of improvisation makes interpreting RR even more challenging. Whilst this could be controlled for by implementing breathing instructions for both resting periods and the singing conditions, the focus in this study was on more naturalistic experiences of music therapy improvisation.

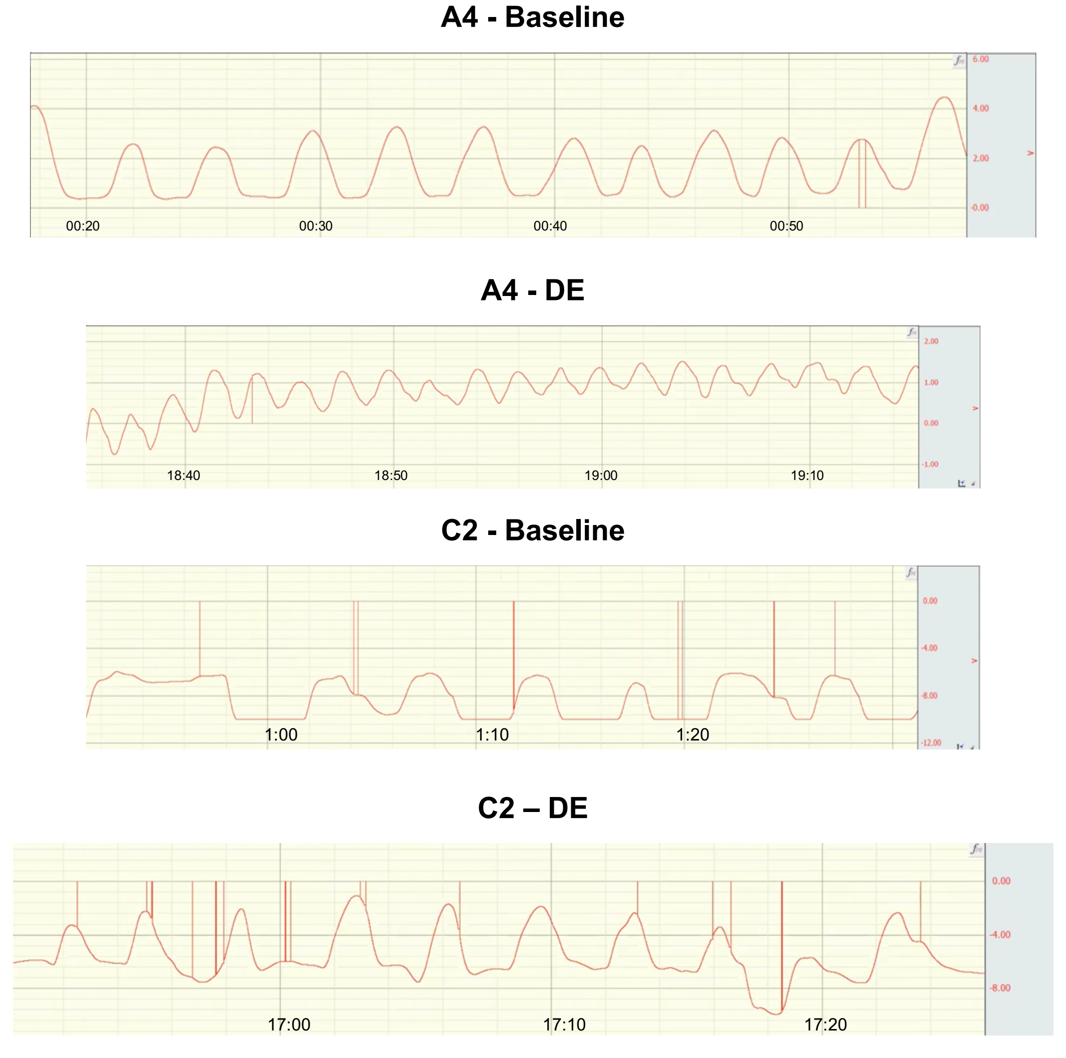
[Figure 17 follows]

Figure 17: Participant B6 Respiration during VI

In cases where improving respiratory function and control might be the focus of music therapy, such as with the neurologic music therapy techniques of Vocal Intonation Therapy or Therapeutic Singing, these findings clearly illustrate that predictable musical structure is essential for regulating breathing. Well-known songs with simple structures allow clients to gradually work towards increasing breath control (Johnson, 2014). For example, with participant B6 (Figure 14), whilst breathing was regular, the participant could be encouraged to work towards singing longer phrases in order to improve respiratory capacity. This is not to say that improvisation is not useful, but rather that clear and predictable musical material should be created in order to sustain regulated vocal output.

The increase in RR for the drumming exercise was also expected as it was a physical activity requiring movement and energy expenditure. There has been very little investigation of drumming and RR. However, group drumming has been considered mild-moderate exercise evidenced by increases in HR (C. Smith et al., 2014), and could therefore be assumed to likely induce increased RR as the body requires higher oxygen intake to cope with the extra demand (Lorig, 2007). Figure 18 shows participant examples of this change from slower breathing to more rapid. It should be noted, however, that RR could not be obtained for several participants during the drumming because of excessive movement disrupting the signal (technical difficulties will be discussed further in section 5.4).

[Figure 18 follows]


A4 - Baseline

A4 - DE

C2 - Baseline

C2 – DE

Figure 18: Participants A4 and C2 Respiration during Baseline and DE

As discussed in the previous HR section, a single physiological variable offers limited insight into psychophysiological processes. The RR served to complement the HR data. The concurrent increase in both RR and HR for the DE component supports a hypothesis of SNS activation or physiological arousal. Drumming can therefore be a useful intervention from the perspective of physical health, offering a low-moderate form of exercise. It may also be a useful tool for clients where an increase in attention and arousal may be beneficial for the therapeutic process, such as in the case of participant C2 who showed limited external response and engagement for other components. This will be explored further in the case examples section.

Reducing the respiration for components that were several minutes long into a single value loses the sense of ‘activity’, preventing observation of changes and variability. Whilst this was a limitation of the statistical analysis, this section has offered a richer exploration and illustration of the activity throughout the components. Within the existing literature there is very little detailed exploration and illustration of respiratory activity as authors tend to report only on the statistical analyses. This exploration may be particularly relevant for music therapists using NMT techniques as the internal mechanisms involved in vocal exercises have been visually represented (Johnson, 2014). It may also offer insight for music therapists working with clients in late stages of dementia where external responsiveness is limited.

5.2.3 EEG

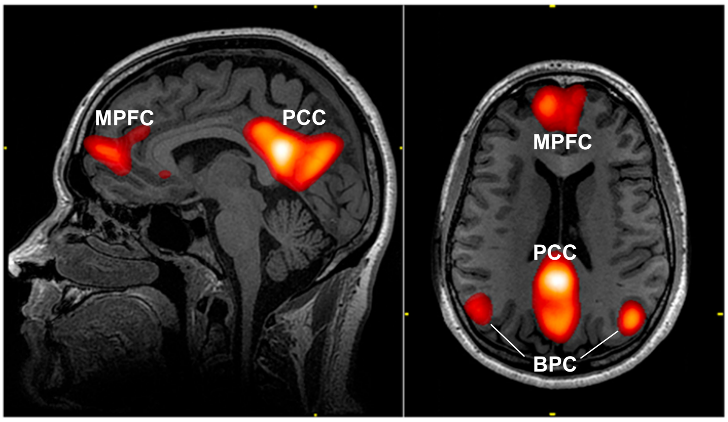
The results of the EEG analysis revealed minimal significant findings. Because of the difficulties faced in the collection and analysis of the EEG data, which will be discussed further in section 5.4, discussion of the results and relevant interpretations are speculative. This section will discuss the key findings in relation to the literature.

Beta appeared to be the dominant frequency band at the prefrontal cortex for all participants. It is typically the dominant frequency band when a person has their eyes open and is alert, particularly in frontal regions (Sanei & Chambers, 2013). Therefore Beta dominance was to be expected as Alpha, which is usually the dominant frequency band in eyes-closed resting conditions, tends to dissipate once the eyes are open. This was not related to the music therapy techniques as this distribution was consistent throughout baseline and music therapy components. However, the consistency of this distribution throughout the groups indicates that even participants with severe dementia, where attention and awareness are often reduced, were of a similar level of alertness as healthy controls and those with mild-moderate dementia.

Whilst a number of studies have observed significant changes in various frequency bands during music listening, no significant changes in EEG activity were observed in either listening components when compared to baseline. It was expected that EEG power would generally increase but this was not observed. Theta, in particular, seems to be implicated in music perception (O’Kelly et al., 2013; Ramos & Corsi-Cabrera, 1989; Sammler et al., 2007), therefore it would also be expected to see clearer changes in Theta activity. Whilst the changes in Theta were very narrow (≤ 2%), there were small increases during VI compared to listening (FL and UL). Increased frontal midline Theta (FMT) may indicate states of creativity and flow, which have been associated with jazz improvisation (Kalmeier, 2016; Lopata et al., 2017). One could therefore speculate that increases in Theta power at frontal electrode sites may have been related to engagement in a creative experience.

Research has shown that Gamma power may be elevated in persons with AD and mild cognitive impairment compared to healthy age-matched controls (Koenig et al., 2005; van

Deursen et al., 2008). This may be a possible explanation for the elevated Gamma power in group C participants. However, as group B showed no difference when compared to group A, this would suggest that only severe dementia contributed to elevated Gamma. Elevated Gamma power in persons with AD is possibly attributed to the changes in the Default Mode Network (DMN). This network involving the medial prefrontal cortex, posterior cingulate cortex and bilateral parietal cortex (see Figure 19) is activated during resting states, internal processing, mind-wandering and meditation (Raichle, 2015). Gamma band activity has been found as a potential indicator of activation and deactivation of the DMN (Chen et al., 2008; Mantini et al., 2007; Ossandón et al., 2011; J. Wang et al., 2017). J. Wang et al. (2017) suggest that because of neurodegeneration persons with AD "use more neural resources to maintain the resting brain state" (p.1), which manifests in generalised increases in Gamma, Alpha and Delta activity.



(Graner et al., 2013)

MPFC = Medial Prefrontal Cortex, PCC = Posterior Cingulate Cortex,
BPC = Bilateral Parietal Cortex

Figure 19: MRI scan showing regions involved in the Default Mode Network (DMN)

Gamma waves are typically associated with intense focus and cognitive processing (Fitzgibbon et al., 2004). Given this association, it is surprising that a large decrease was found for the DE in group C where four out of the five participants showed a decrease of 15–21% in absolute Gamma power. Of the five components it was the most cognitively demanding and induced greater motor activity. This suggests that a reduction in Gamma power may be associated with these task-related features. Furthermore, this reduction was not observed in any other participants. This suggests that severe dementia possibly played a mediating role. Unfortunately there is an absence of research exploring the electrophysiological effects of drumming with which to compare these findings. Therefore, possible explanations have to be drawn from elsewhere.

DMN activation can be indicated by increased Gamma power in frontal regions (Chen et al., 2008; Mantini et al., 2007). The DMN becomes deactivated when attention is shifted to the external environment or a task (Raichle, 2015), which has been associated with decreased Gamma power (Ossandón et al., 2011). Ossandón et al. (2011) found that Gamma suppression, or reduction, occurred during a visual task, compared to resting baseline, especially in the higher Gamma range of 60–140Hz. Interestingly, the four participants with elevated Gamma power also had elevated mean frequency (Baseline mean frequency 60Hz, DE 43Hz) indicating a potential suppression of high Gamma. It is possible then that the DE component deactivated the DMN in the four participants and increased awareness and engagement with the environment. This finding of Gamma suppression could suggest that structured rhythmic work may orient persons with severe dementia to the present moment, increase focus on a task, and allow for overactivity to be replaced by neural balance. Structured rhythmic work may reduce the need for compensatory neural activity and therefore induce neurophysiological regulation. This deactivation may not have been observed in other participants as there may have been more consistent awareness and attention paid to the external environment throughout baseline and music therapy components. Therefore, when working with persons with severe dementia, even when they may appear alert during other music therapy techniques, including structured rhythmic work may offer experiences of greater awareness and engagement with the external environment and neurophysiological regulation.

Another possible explanation may be a change in anxiety levels. Elevated Gamma power has been observed in persons experiencing feelings of anxiety, worry and uncertainty (Knyazev et al., 2005; Oathes et al., 2008). Reduction in anxiety levels has been shown to correlate with an increase in Theta power (Suetsugi et al., 2000), however only small increases (3–6%) in Theta were found in two of the four participants whilst the others decreased. There were no similarities in responses in the other frequency bands. Anxiety symptoms are highly prevalent amongst persons with various forms of dementia (Ballard et al., 2000; Porter et al., 2003). Therefore, if the decrease in Gamma is a reflection of reduced anxiety, this would motivate for including drumming, or structured rhythmic work, as a technique in music therapy with persons with severe dementia as a means to reduce anxiety.

This change may also have been a result of movement-related signal interference or medication-related responses. Firstly, increased movement during the drumming may have interfered with the signal as muscle activity, including micro-movements of the eye, can appear as increased Gamma band activity, therefore leading to inaccurate conclusions (Hipp & Siegel, 2013; Schwartzman & Kranczioch, 2011). However, it would then be expected that a significant increase would be seen as opposed to a decrease. Furthermore, it is surprising that this effect was not observed for any other participants, as all were involved in the same level of movement. Secondly, medications such as benzodiazepines, antidepressants and antipsychotics, may impact EEG activity (Bauer & Bauer, 2005). However, no clear differences in medications were observed between the four participants of interest and the rest of the sample. The exclusivity of this effect to group C raises questions about the potential influence that severe dementia has on Gamma activity during drumming and what this may mean for music therapy practice. This would be a valuable topic of future research.

This research is novel in its investigation of real-time EEG activity both during a range of active and receptive music therapy techniques and with persons with dementia. More substantial findings from the EEG data would have served to complement the cardiovascular and respiratory data and offer insight into the differences that were found between receptive and active approaches. Whilst the EEG results contribute no clear answers to the overall research questions, the findings related to Gamma power differences between groups and the changes during the DE offer an interesting area for potential future research.

5.3 Case Examples

This section will present and discuss four significant participant cases. The case examples were chosen based on significant moments that illustrate the qualities of participants' experiences of the music therapy components. Each case will include a profile of the participant, the general context of the session, and a descriptive vignette for significant moments. Vignettes were written based on excerpts from the video footage, which were selected through supervision. The case content will then be discussed in relation to the literature and neurophysiological data. To conclude, a summary of the observations across the sample and between groups will be given. The case examples do not serve as a formal source of qualitative data but rather as a means to provide context and meaning to the quantitative data.

5.3.1 Case 1: Improvisation, creativity, and orientation to the present

Participant C1, referred to here as 'S', is a 79-year-old female diagnosed with probable Alzheimer's Disease, hypertension, and type 2 diabetes (refer to Table 4 for medication information). S presented with severe memory impairment, labile mood, disorganised speech, disinhibition, and regressive behaviour. In the specialised dementia unit she requires constant supervision as she can become easily distressed, aggressive, and inappropriate.

During baseline and resting periods S was restless and talked throughout. In the listening components, S often responded through movement but had difficulty staying seated, and continued talking throughout. In the active components she was able to sustain attention and engagement. There were many moments of distraction and disorganised speech, but she was easily reoriented to the musical task when prompted. Vignette 1 is of the VI component where S was often distracted but reoriented to the music.

Vignette 1: Participant C1 VI case example

> *As the guitar introduction begins, S bursts into movement, clapping and swaying. She leans over to the drums, tapping rhythmically as I sing. I prompt S to leave the drums for now and just sing but she is distracted, telling an incoherent story about her mother as if she is still a child. S occasionally joins in singing after repeated prompting, though still partially distracted by the drums and her story. I sing a rhyme S had told me earlier, which captures her attention, she continues moving and clapping in time as she listens, smiling and occasionally joining the lyrics. S suddenly leans forward sticking her tongue out, I improvise a short rhythmic phrase reflecting this action, after which S bursts out laughing, taken by surprise. I incorporate laughter into my singing, which turns into a playful exchange: each taking turns to sing 'ha ha ha!' at different pitches. S suddenly says she is "going home now". I prompt her to sing with me and she responds "yes I can!". This turns into a musical call and response, where I repeatedly sing "S can you sing for me?", to which S rhythmically responds "yes I can!". As I return to the original vocal motif she immediately joins me. As we approach the ending S is distracted again by the drums, telling another story, however as I slow down, singing the final phrase, S spontaneously joins me in singing the cadence, makes eye contact, matches the exaggerated pause and anticipation of the resolution, as we finish completely in sync.*

In this description S demonstrates behavioural disinhibition and regressive behaviour, and verbal disorganisation. These behavioural features of dementia may be socially inappropriate in many contexts, however within the container of musical improvisation they were transformed into playful creative expression, which facilitated connection.

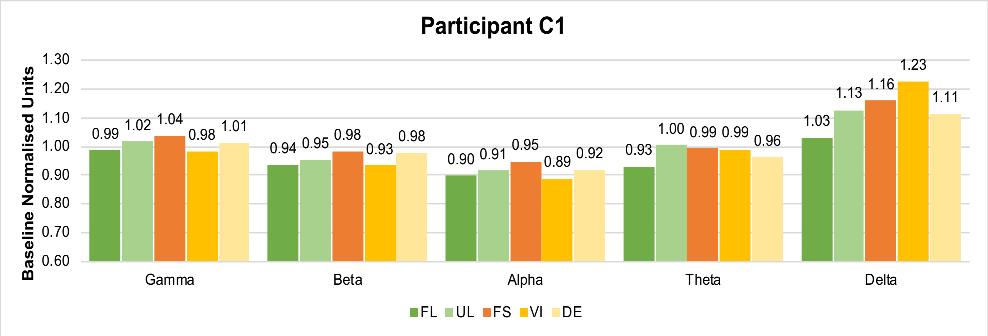
In the listening components, the musical stimuli, or ‘acoustic properties’ evoked strong movement responses but these responses were not sustained. However, the active music-making and therapist interventions helped to sustain engagement and create continuity of experience, which contrasts with the fragmented quality of her verbal engagement. Ansdell (1995) suggests that the flow of music can “[compensate] for the scattered, the incoherent and the discontinuous” (p.140). Spontaneous matching and reflecting of her responses allowed her ‘distractions’ to become part of the music. Improvisation, therefore, offered a rich experience of play and creativity.

Awareness and perception of time can be distorted for persons with dementia. Time is often judged as passing quicker in AD as short-term memory is significantly impaired (El Haj & Kapogiannis, 2016), there may be loss of time structure within an activity (Aldridge, 2005) and persons may regress to previous life stages as these remote areas of memory are more intact. S displayed disorientation to time and reality, evidenced by her verbal comments, and was easily distracted. Active music-making provided concrete tasks for S and oriented her to the present moment, the task at hand, awareness of herself and the interpersonal interaction. This example, therefore, supports Parsons' (2019) suggestion that musical improvisation offers a mindful experience for persons with dementia.

5.3.1.1 Case 1 Neurophysiological Response

This participant’s responses were overtly and externally observable but these responses are not clearly reflected in the neurophysiological data. S showed an increase in HR from baseline for all components, however this remained elevated for most of the resting periods. Because of the her constant movement, the Respiration data had a high level of signal interference but appeared highest in the FL and DE, during which her physical movement was greatest. S only had a short 30-second baseline measure against which to compare changes.

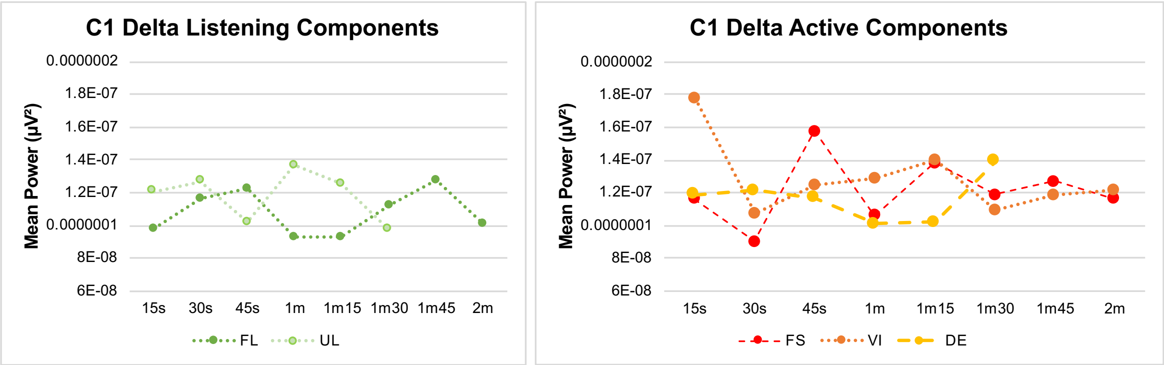
The EEG data showed several decreases in the Alpha band and increases in the Delta band (Figure 20). Decreases in Alpha may indicate increased brain activation (Pizzagalli, 2007). Whilst Delta is typically associated with states of lower consciousness, given its involvement in sleep, increases in Delta power have also been associated with concentration and cognitive processing (Harmony, 2013), however it is then surprising that the UL component showed a greater increase in Delta power than the DE, during which C1 showed more focus and concentration on the task.



*For ease of reference and representation values have been normalised against the baseline (i.e. a value of 1.05 indicates an increase of 5%, a value of 0.95 indicates a decrease of 5%)

Figure 20: Participant C1 EEG power relative to baseline

Figure 21 shows the time-based Delta activity for all components. It is possible that the peaks in Delta power are movement-related as C1 was often dancing. Body movements, particularly head movements, can create temporary slow-wave rhythms that resemble Delta or Theta rhythms (Sanei & Chambers, 2013).



FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise

Figure 21: Participant C1 time-based Delta activity

5.3.2 Case 2: Quickening

Participant C2, referred to as D, is a 69-year-old female diagnosed with probable AD, type 1 diabetes and asthma. She presented as calm but withdrawn and no demonstration of verbal communication or interpersonal engagement. She spends the majority of the day laying down as her physical mobility is limited.

During baseline and resting periods D was very still, occasionally looking around the room, and sporadically tapping her toes. During the listening components she showed little external responsiveness. She often tapped her toes but this was not entrained to the music. She did not vocalise during either of the singing components. She showed some awareness of me in the familiar singing and this increased in the vocal improvisation, during which very briefly she tapped her hand in time to my music, mirrored my head movements and increased eye contact. Her external responsiveness increased in the DE, which will be illustrated in Vignette 2.

Vignette 2: Participant C2 DE case example

> *I begin playing gently on the drum, sitting beside D, matching the tempo of her small rhythmic hand movements as she grips the wires of the HR monitor. I take her hand and hold it as we play the drum together. I tap gently and steadily, D looks around, down at our hands and then at me. I softly sing a short melodic motif alongside the beat, responding to D's quiet energy. Slowly and gradually her feet begin tapping to the beat, her body begins to very subtly rock and she makes and holds eye contact with me. She begins to control our hands' movement, initiating a brief burst of intensity as her body rocks, her foot taps become larger and the volume increases. The intensity then fades, her movement stops, the volume decreases and the tempo slows. D loosens her grip and her gaze shifts away. This cycle of rise and fall repeats several more times until I bring the music to a close. As I thank D for making music with me and the technician begins removing the equipment, she continues holding my hand and maintaining eye contact until it is time for her to be taken back to her room.*

Although these external responses are very subtle, they are markedly different from her presentation in the other components. The brief, but powerful, rises in intensity could be explained as 'quickening', which means "to impart energy" (Ansdell, 1995, p.80). Ansdell writes how a particular therapeutic benefit of music is how it shares its "qualities of liveliness and motivation to both body and spirit" (p.81). He further suggests that quickening is when motion and emotion connect. Without an emotionally meaningful response there is no motivation. For D, something within the musical exchange motivated her to respond in a way that other exchanges did not.

In comparison to the other components, the DE was significant in that D was able to physically engage in the active music-making when she was assisted. Music therapists often work on facilitating music-making in situations where clients may lack physical mobility. Whilst she did not have access to melody through voice, D still had access to rhythm as a tool for expression and communication. Clair et al. (1995) promote the use of rhythmic activities with persons with dementia for this reason as rhythm gives access to meaningful musical experiences. Rhythm here, in the form of beating a drum as well as body movement through rocking and toe-tapping, allowed for D to communicate her internal experiences.

Although the DE was intended to involve only drumming, there was a sense that melody was needed in the moment. Because of D's physical limitations, her rhythmic vocabulary available was also limited. Furthermore, we were playing while holding hands which resulted in only one rhythmic line. Whilst rhythm offers basic continuity, it is melody that can provide direction (Ansdell, 1995). In this case, melody added movement, direction and texture. The music was improvised according to qualities of D's being and responses: this music therapy technique is referred to as matching (Wigram et al., 2002). It is perhaps these qualities of the music created that D found moving.

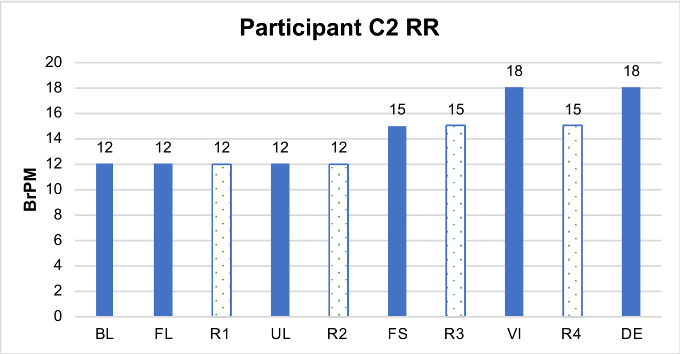
One can speculate about which elements of the musical improvisation contributed to D's quickening. However, as Ansdell (1995) argues:

> "It is music as a whole that quickens - which is to say gives life and fluency and ease back to a person - and this is mediated through the creative and musical relationship that improvisation in creative music therapy can make accessible to clients." (p.86)

Through the therapeutic relationship, D was given access to music-making but the interaction also facilitated social connection. Firstly, there was a sense of meeting in the music - that is a sense of shared thought, feeling and intention (Ansdell, 1995). Secondly, the experience of physical touch, use of voice, and close supportive direction created a further sense of connection. Physical touch, in the context of music therapy with persons with late-stage AD, has been shown to increase non-verbal communication and rapport between client and therapist (Belgrave, 2009). A lack of social connection is reported as one of the most significant losses persons living in long-term care facilities experience (Roos & Malan, 2012). For D, who spends most of the day alone, lying down, experiences of connection and interaction may therefore be significantly lacking. For a client such as D, where she is in the advanced stages of AD, the focus of music therapy may not be about altering disease progression or even change beyond the session, but rather facilitating meaningful moments of connection and communication as a means to preserve personhood and dignity.

5.3.2.1 Case 2 Neurophysiological Response

In a client case such as D, where external responses are very subtle, even basic autonomic data could provide insight into the client's experience. The RR data shows a visible increase for the active components, particularly the VI and DE (Figure 22). Whilst the preceding resting periods do not return to baseline, they are still lower than the RR during the components. This is particularly interesting as D did not sing therefore respiration was not interrupted by singing. This then may be in response to the live and entrained music performance.

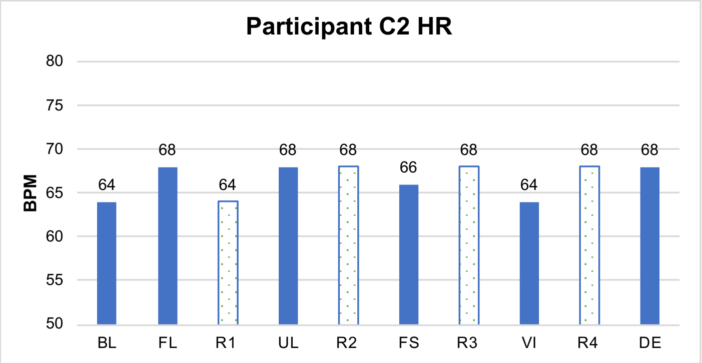


BL = Baseline, FL=Familiar Listening, UL = Unfamiliar Listening,

FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise

Figure 22: Participant C2 RR

The HR data does not offer as clear a picture, as the DE is the same as the receptive components and most of the resting periods (Figure 23). This might suggest, however, that even though there was little external responsiveness during the listening components, D was aware of and affected by the music.

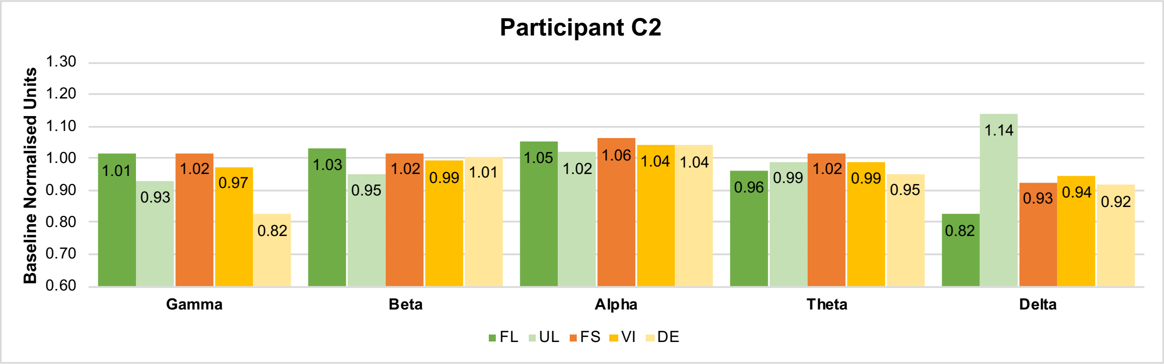


BL = Baseline, FL=Familiar Listening, UL = Unfamiliar Listening,

FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise

Figure 23: Participant C2 HR

The EEG data possibly offers some insight into D’s levels of consciousness and awareness. Unlike participant C1, D showed decreases in Delta for the active components (Figure 24). An unexpected increase in Delta power and decrease in Beta power, for the UL was attributed to a spike at the end of the component (Figure 25). D appeared to become very drowsy therefore this would likely explain the sudden change. It is possible therefore that the music had a relaxing or sedative effect. Ogata (1995) found that participants had increased Delta power during drowsiness whilst listening to white noise and sedative music.



*For ease of reference and representation values have been normalised against the baseline (i.e. a value of 1.05 indicates an increase of 5%, a value of 0.95 indicates a decrease of 5%)

Figure 24: Participant C2 EEG power relative to baseline

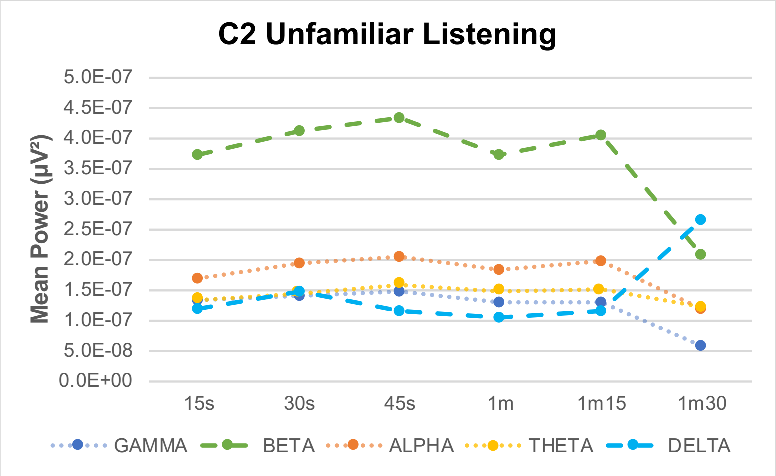


Figure 25: Participant C2 time-based EEG activity during UL

D is an example of the significant decrease in Gamma power during the DE. She was most engaged and alert during the DE, therefore this change is unexpected. As discussed previously, this could possibly indicate deactivation of the DMN and a turn to awareness of the external environment. Observing the inverse relationship between Beta and Delta for this participant may give insight into levels of consciousness during the DE component. (It should be noted that this relationship was not clear for other participants.) The moments of rising intensity described in Vignette 2 correspond temporally with the peaks and troughs of Beta and Delta activity shown in Figure 26. Therefore it could be suggested that the moments of intensity indicated moments of increased awareness and communication. However, as each

Epoch is an average of the activity over a 15-second period, it is difficult to pinpoint these exact moments.

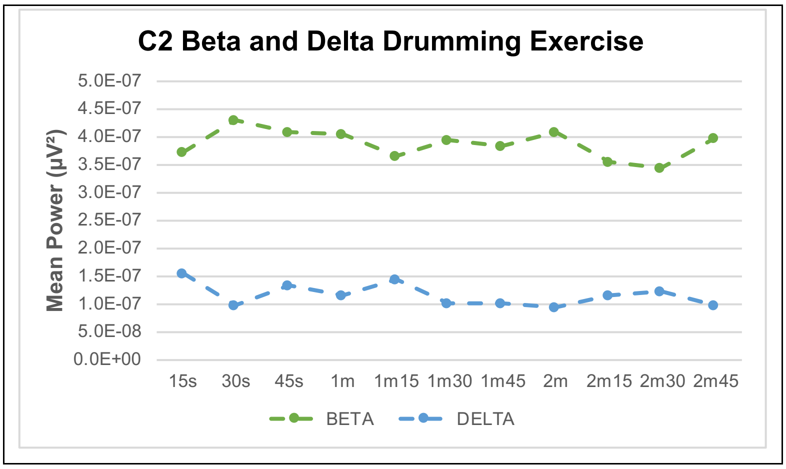


Figure 26: Participant C2 time-based Beta and Delta activity during DE

5.3.3 Case 3: Familiarity, Repetition and Engagement

Participant C3, referred to as J, is a 92-year-old man with probable dementia (unspecified as he was awaiting assessment) and hypertension. He presented as calm but somewhat disoriented and detached. He would initiate conversation but was difficult to follow because of disorganised speech.

During baseline and resting periods J was very calm and quiet, though occasionally he would talk or whistle very softly. During the listening components his presentation was similar, with some acknowledgement of the music. In the active components J was more engaged, though often required prompting to enter into or sustain participation. Vignettes 3 and 4 illustrate how in the FS and VI components, intervention and prompting brought J back into participation and the role that familiarity and repetition played in encouraging participation.

Vignette 3: Participant C5 FS case example

J and I sing the first verse of 'Amazing Grace' together, his voice is very present and he maintains eye contact throughout. When I introduce a variation singing the melody on 'La' he stops. However, after prompting him twice he joins in. Our music is cohesive and flowing. I introduce another variation where I hum the melody. With this change, again, J stops. After prompting he joins. He starts to sing on different sounds 'her' and 'ler', which I mirror. When I return to the lyrics, J joins immediately without prompting, his voice coming through clearly. There is a rise in intensity and the music becomes louder. At times J stops briefly, but spontaneously re-joins. J *stops as I begin singing the final phrase, I pause for him to join me on the last note but he just looks at me so I bring the song to a close. Afterwards, I say to J "nice J!". In a serious tone he responds "very". I ask "it was very nice was it? Nice to sing together?". He says "Very very, very. Completely very nice." I add "I'm glad. It's a beautiful song" to which he agrees "yes a beautiful song". He then begins telling a story but quickly loses his train of thought, commenting "my kop draai" [my head spins]. He whistles a few notes of Amazing Grace before talking again.*

Vignette 4: Participant C5 VI case example

As I begin playing, J is very focused on me and my guitar. I prompt him to join in with my improvised vocal melody but he shakes his head subtly and continues looking at me with a blank expression. I continue singing and he begins to nod his head, appearing more interested. When I prompt him again to sing, he seems to try but retreats. I sing "J J will you sing with me? Lalala will you sing with me?". I sing another new melody, but J still doesn't join. As I switch to ¾ time, playing a slow lilting accompaniment, and singing a smooth sighing melody, J suddenly sits up straight and briefly leans forward looking at me intensely, then sits back again. I prompt him to sing with me, the second time he joins, we repeat the short motif several times together. However, when I change to a new melody J stops singing. When I return to the previous motif and prompt him repeatedly, he eventually responds. This time smiling as he sings with more volume and tapping his foot to the beat. His voice comes through strongly. As I vary the melody, again he stops singing but continues smiling. He appears to be whistling, though inaudibly, and I match his mouth shape, singing on 'oo'. I begin slowing down, bringing the music to a close. At the cadence, I pause after the penultimate note in anticipation of the resolution. At the same time as I begin to ask 'what's our last note?' J is already prepared to sing. We sing together in unison for the final note.

The purpose of repeated prompting and intervention was to bring J back into awareness of himself, the music and the interaction. Although he appeared engaged, because of his fixed gaze, he often did not respond to prompts to join in singing. This may have been due to limited awareness or not being motivated to participate at that time. Parsons (2019) describes how musical centring, where client and therapist are focused on the same temporal structure, can support persons with dementia to become oriented to time and reality. The moments where J became fully oriented to the shared musical experience, facilitated connection and an emotionally meaningful experience.

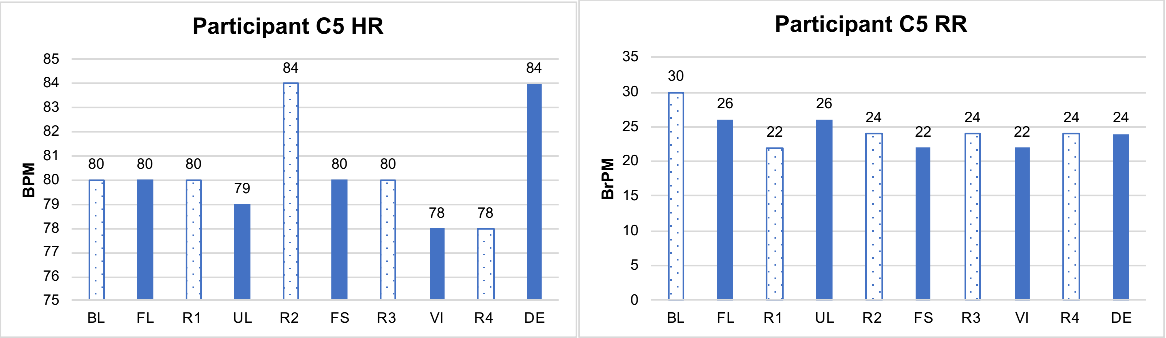
The familiarity of the musical material in both the FS and VI components influenced J's participation. In the FS component, J often stopped singing when the song was varied and in the VI he more readily joined in singing if the melody had been repeated several times. Using familiar music can be a way to "[enter] into dialogue" when working with persons with dementia (Ridder, 2003, p.2). For J, the familiarity of a stimulus may capture attention more easily than unfamiliar stimuli. In the VI, it was both familiarity and simplicity. Short melodic motifs that could be repeated easily seemed more inviting to J. In order to create musical stability in clinical improvisation with persons with dementia, which invites and sustains attention and awareness, Parsons (2019) recommends the repetition of simple and clear musical ideas. For J, spontaneity may be challenging, however these music therapy techniques invited him into experiences of spontaneity.

Whilst J was talkative and motivated to engage in conversation, his speech was disorganised making it challenging to hold a conversation. It appeared that this was frustrating for him, commenting that his head was "spinning" when trying to tell a personal story. However, the moments after the music-making finished he engaged in short and coherent conversations about the music itself. Therefore within the music and after, there were moments of more synchronous communication. Music therapy has been found to improve speech quality in persons with dementia (Brotons & Koger, 2000). Whilst J's responses may be a result of exposure to music, they may also be attributed to the activity providing conversation material that remained in the present moment, therefore, avoiding reliance on autobiographical memory.

For J, despite marked memory impairment, he was still able to effectively perceive, process and engage in music-making. Whilst coherently telling a story was challenging, he was able to fluently sing the lyrics of a full verse of *Amazing Grace*. Even in the VI component where the material was unfamiliar, the use of a familiar musical structure such as the perfect cadence, captured J's attention as he sang the musically logical final note independently. He was able to perceive the dynamic qualities of the melody, knowing where it was leading by making sense of its "tensions and resolutions" (Ansdell, 1995, p.84). Whilst verbal language may become unreliable, communication through music remains accessible as its syntax and grammar remain largely intact.

5.3.3.1 Case 3 Neurophysiological Response

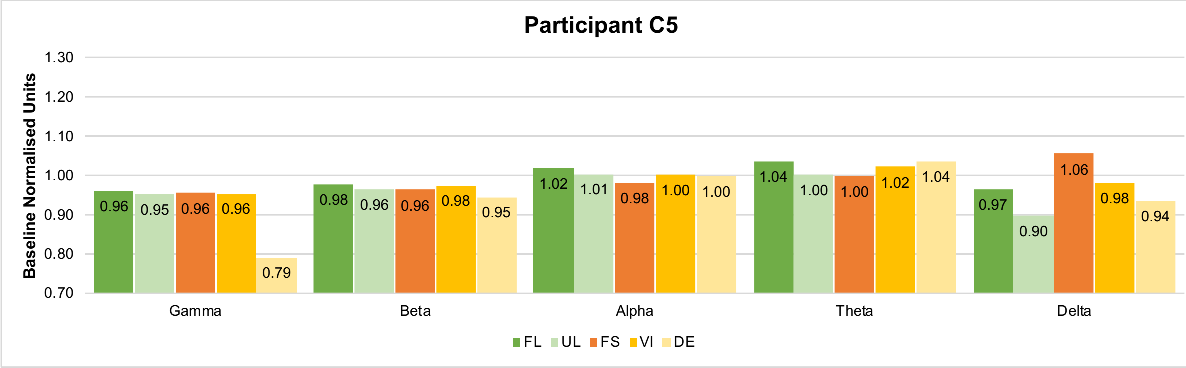
The trend of increased HR during active components is not clearly evident for J (Figure 27). HR unexpectedly increased during resting period 2, with no indication of what may have caused this. J remained still throughout, whistling quietly to himself. HR then returned to baseline in FS, and decreased during the VI component. However, HR increased in line with the trend for the DE component. J remained very still throughout the session (excluding the DE component) except for very brief moments where he leaned forward. J's RR decreased for the entire session from baseline (Figure 27). Unexpectedly, RR was higher in the receptive components compared to the active components. This could indicate that while J showed minimal response to the music-listening externally, he was possibly having a more active internal response.



BL = Baseline, FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing, VI = Vocal Improvisation, DE = Drumming Exercise

Figure 27: Participant C5 HR and RR

J is another example of a significant drop in Gamma during the DE (Figure 28). During the exercise he was able to copy rhythmic patterns, follow changes and responded when he was invited to improvise his own rhythmic patterns. There was a sense of J engaging consistently, which is in contrast to his participation in the other components.



*For ease of reference and representation values have been normalised against the baseline (i.e. a value of 1.05 indicates an increase of 5%, a value of 0.95 indicates a decrease of 5%)

Figure 28: Participant C5 EEG power relative to baseline

Delta was generally lower than baseline throughout the UL, however this was not accompanied by an increase in fast-wave activity, therefore, it is unlikely that it indicates an increase in awareness and attention. The increase in Delta during FS was attributed to spikes at the end, however these do not correspond with Beta or fast-wave changes which would possibly indicate reduced awareness. Furthermore, at that moment J appeared aware and was singing along therefore it may have been movement-related as discussed the case of C1.

5.3.4 Case 4: Self-Expression and Identity

Participant B5, referred to as N, is an 81-year-old woman. Whilst N has no formal diagnosis of dementia, staff reports, assessment, medication and presentation indicate mild to moderate dementia. N presented as pleasant and engaging. Short-term memory impairment was evident as N did not recall our meeting an hour later and often repeated herself during the session. N was a music teacher for most of her life.

During baseline and resting periods N was calm and relaxed. She often began commenting on the scenery outside. In the FL component she responded instantly with movement, showed positive affect and engaged in eye contact and non-verbal gestures. In the UL component she was silent throughout and appeared relaxed. Vignette 5 will illustrate N's response to the FS component, and her musical confidence and expressiveness. Whilst N was engaged during the VI component she was more hesitant in her participation. She was focused throughout the DE component, and was able to copy and create rhythms with ease.

Vignette 5: Participant B5 FS case example

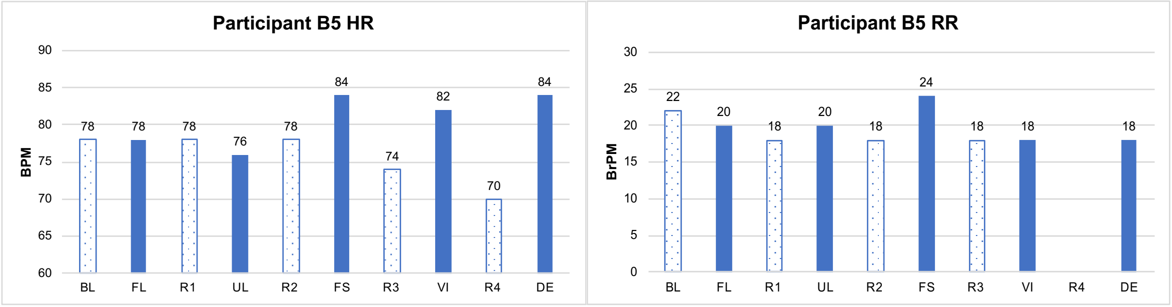
> *After a short guitar introduction, N and I begin singing 'You are my Sunshine'. She smiles as she sings, alternating between making eye contact and closing her eyes. Our phrasing of the melody is in sync as if we are a well-rehearsed duo. N mirrors my changes in articulation as I move from flowing and lyrical to detached and bouncing. There is a sense of playfulness between us as we both exaggerate the sharp and short ending of each phrase. I return to the original flowing and lyrical style as we hum the melody. The music is gentle. When I return to the lyrics N incorporates spontaneous harmonies. Her face is expressive as if she is on stage performing. In the final phrase I slow down in anticipation of the cadence, N looks expectantly as we hold the penultimate note before ending in two-part harmony.*

The emotional qualities in N's musical and non-verbal expression indicate a likely meaningful and moving experience. Singing a familiar song allowed N to perform her musical identity with confidence. Within her musical identity is also the social role identity (Moen et al., 2000) of a music teacher. According to Goffman (1963), identity is performative and constructed in interaction with others. Music-making can be a useful tool for performing the self and identity; not only in cases like N's where there is previous musical experience but for all individuals who will engage in music. In all the previous case examples this applies: music-making allowed parts of self to be revealed that were not shown outside of music-making. As is often the case in working with persons with dementia, music therapy can offer experiences for clients to reconnect with parts of self that were previously productive and able.

Whilst N and I were able to meet in verbal communication, having fluent conversation, our meeting in music added a different dimension to the relationship. Because of N's memory impairment, she may have difficulties forming and maintaining new relationships. Many older adults in residential care and particularly those with dementia, experience isolation and a lack of social connection (Roos & Malan, 2012; van Biljon et al., 2015). Group music-making, in particular singing, can be a powerful tool in remedying this (Cho, 2018; Hara, 2011; Lesta & Petocz, 2006). Whilst these interventions may not repair memory impairments, they allow access to frequent meaningful interactions and a resulting improvement in quality of life in general.

5.3.4.1 Case 4 Neurophysiological Response

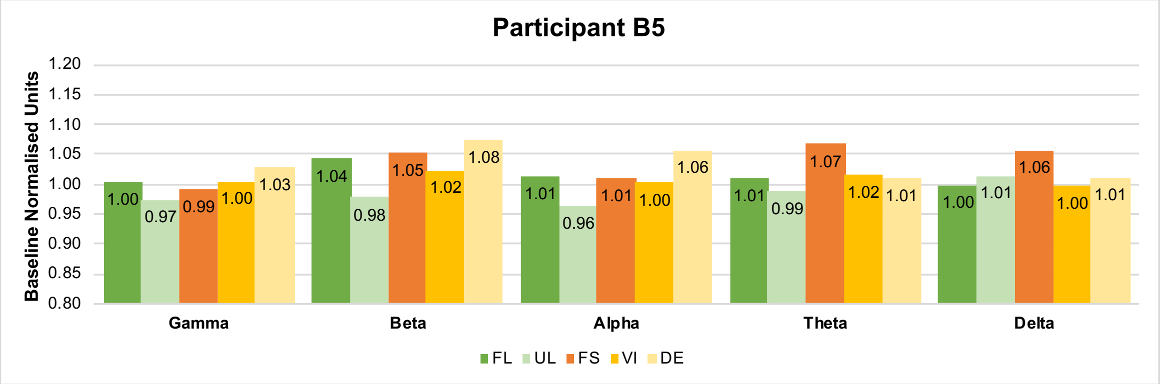
N is a clear example of a heightened cardiovascular response during the active components (Figure 29). There were large increases for the FS and DE components. Interestingly, HR was lower in the resting periods after the FS and VI components. This perhaps speaks to previous studies that have shown activation of the PNS system after active music-making (McPherson et al., 2019; Ridder, 2003; Sakamoto et al., 2013). RR appeared to be less predictable, however N's respiration data was highly artefactual.



BL = Baseline, FL=Familiar Listening, UL = Unfamiliar Listening, FS = Familiar Singing,
VI = Vocal Improvisation, DE = Drumming Exercise

Figure 29: Participant B5 HR and RR

The EEG results show slight elevation of fast-wave activity during the DE (Figure 30). This is possibly because of an increase in concentration and focus. The large spike in Beta power seen in Figure 31 may be a result of increased focus as this was when N was improvising rhythms. However, in the footage she is smiling and contractions in facial muscles can resemble Beta waves.



*For ease of reference and representation values have been normalised against the baseline (i.e. a value of 1.05 indicates an increase of 5%, a value of 0.95 indicates a decrease of 5%)

Figure 30: Participant B5 EEG power relative to baseline

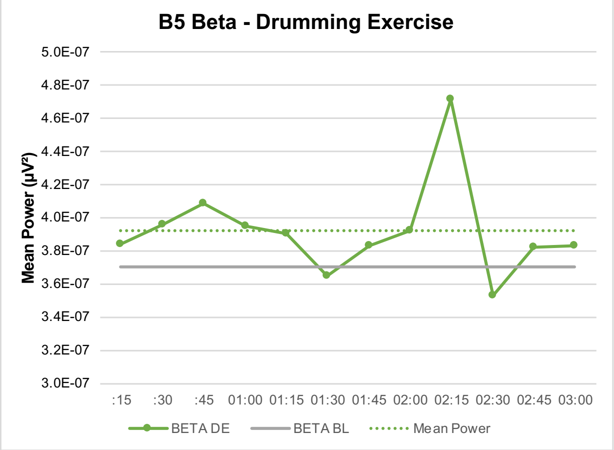


Figure 31: Participant B5 time-based Beta power during DE

In the FS component there were increases in Beta and slow-wave activity. This may be related to more intense focus and attention as well as engaging in a creative and expressive activity. The decrease in Beta towards the end of the song (see Figure 32) may be where the singing changes to humming, as described in Vignette 5, with the subsequent increase reflecting the return to lyrics and harmony. However, as with the DE, these changes may also be associated with movements.

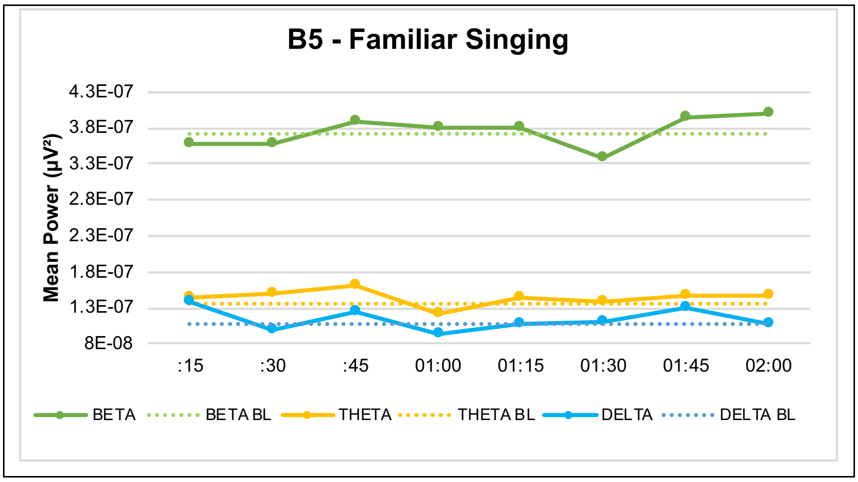


Figure 32: Participant B5 time-based Beta, Theta and Delta power activity during FS

5.3.4 Summary and Further Reflections

The neurophysiological data offered little insight into group differences, however the observations and case examples reveal some differences. Groups A and B showed little difference in their level of participation. Participants that were frailer and had physical limitations did show differences in the DE component but this appeared to be unrelated to the presence of dementia. Differences in presentation and participation were clearer for group C. Participants generally had more difficulty sustaining attention and musical engagement, evidenced by beginning to talk during the musical tasks or withdrawing musically. However, the group was highly heterogeneous in their presentation ranging from non-verbal to being able to accurately recall memories and disinhibited to withdrawn.

The case examples illuminate the difficulties faced in capturing the observed participants' experiences in the neurophysiological data. Case 1 showed how participants were sometimes very physically active which impacted on signal quality. Cases 2, 3 and 4 illustrated the inconsistency and variation of the results. Whilst there were limited findings in the EEG data overall, case 2 explored a possible relationship between Beta and Delta power and levels of consciousness and awareness. Therefore, the physiological data may have been useful in these circumstances for giving insight into experiences that were not reflected externally.

It was clear that both the receptive and active techniques stimulated reminiscence for several participants throughout the three groups. Music often triggers personal memories (Baumgartner, 1992) and may even improve autobiographical recall after exposure (El Haj et al., 2012; Irish et al., 2006). This was not directly investigated in this study, however instances of spontaneous reminiscence were present in groups B and C (participants in group A generally remained silent during the baseline and resting periods). For example, after the VI component participant B3 began talking about how she used to spend Friday evenings listening to music with her husband and after the FS component participant C3 recalled how she used to hear the song on the radio and listen with her brothers. Therefore, experiences of listening to, and making, music with other people can offer opportunities for reminiscence, meaningful conversation and connection for persons with both mild-moderate and severe dementia (Dassa & Amir, 2014). For some participants, however, reminiscence was inaccessible or challenging as their speech was disorganised. In cases such as these where words become unreliable, music offers a means through which to communicate.

Familiarity can offer a sense of safety. During the vocal improvisation, many participants throughout the groups showed hesitation. Being asked to sing as well as improvise in front of another person may have been very challenging. Wigram (2004) cautions that clients may find improvisation challenging or uncomfortable as it is unlikely they have experience or training. Some participants felt they lacked creativity (B2) or a "good singing voice" (C3). There was a sense of participants' inhibitions making participation difficult. Participant C1, for example, presented with clear disinhibition and as a result improvised with more confidence. For C5 it was not clear whether hesitant participation was a result of inhibition or limited awareness and communication. This cannot be generalised to the rest of group C as this group was heterogeneous.

Whilst statistical differences between groups were modest, the integration of the neurophysiological responses and case examples shed light on implications for working with clients across the dementia trajectory. In cases where a music therapist is working with a client that is showing gradual deterioration, the nature of the work may change as the disease progresses. In the early to mid-stages of dementia, receptive techniques may still engage clients fully and offer opportunities for reminiscence. In the later stages a shift of focus towards active, structured and rhythmic work may elicit greater engagement and awareness, which in turn facilitates communication and connection. The neurophysiological findings suggest that these techniques may induce greater physiological arousal and possibly affect neurological levels of attention and awareness.

5.4 Limitations of the Study

Whilst there are some notable results, this study had a number of limitations. The small sample size, range of physical health conditions, lack of formal dementia diagnoses and inconsistencies in the delivery of the intervention may have impacted the results and therefore limit the interpretation of findings. There were numerous technical difficulties associated with the neurophysiological data collection and analysis, which may have affected the results. Each of these influencing factors will be discussed in relation to the findings and recommendations for future research.

The small sample size poses a number of challenges. Analyses of data from very small samples and groups carry a greater risk of statistical error (Button et al., 2013). As was illustrated in the presentation of the results, the groups varied greatly and there were often statistical outliers, which therefore make statistics such as the median and mean less representative of the group. Individual differences naturally occur between people, particularly in complex interventions where there are many influencing factors. Norberg et al. (2003) note that people may have "opposite qualities of experience" (p. 477) during exposure to music, as was found in their small study of two individuals with late-stage AD. Music may have a relaxing effect for some whilst a more stimulating and excitatory effect for others. Furthermore, the same piece of music may evoke feelings of excitement for some, and sadness for others. Differences in emotional memories associated with certain musical stimuli, as well as other personal characteristics such as previous musical experience and musical preferences, may play a mediating role in a person's response. To control for all of these factors would be extremely challenging, which therefore motivates for the use of a much larger sample. The small sample size, however, allowed for more in-depth exploration of individual participants' experiences and uncovering potential areas of interest for future research that may have been overlooked in a larger sample.

The majority of the participants had health conditions and were taking medications that could have potentially impacted their neurophysiological response. For example, Beta-blockers are associated with lower heart rate (Materson et al., 1998). This could have been controlled for in group A, however due to time and resource constraints these participants could not be screened. Moreover, this was potentially advantageous as there was an element of matching between the three groups. Other studies have controlled for persons with health conditions and taking medications that impact ANS functioning, such as hypertension and heart disease treated with medications including beta-blockers. Medications used to treat psychiatric conditions such as benzodiazepines or antipsychotics, may impact neurological functioning. However, these studies were not generally within older or clinical populations where lifestyle diseases are very common and difficult to avoid (Bernardi et al., 2017; Etzel et al., 2006; McPherson et al., 2019; Nakahara et al., 2011). There is also evidence that among the elderly, ANS changes, such as fluctuation of HR, may be smaller (Levenson, 1992). Attempting to compare older adults, and persons with multiple health conditions, with studies of younger healthier populations is therefore challenging. Future studies should ideally have both healthy age-matched controls as well as persons with health conditions in order to have a representative sample.

There was a lack of formal diagnoses of dementia, particularly in group B, which resulted in uncertainty of the type of dementia and the severity. In the planning of this study, it was anticipated that a psychiatrist would assess all participants, however this did not materialise. Whilst it is likely, based on the assessment and recruitment process (detailed in section 3.3), that all participants were experiencing symptoms of dementia there cannot be certainty. Within the existing body of research there is a call for further investigation of types of dementia other than AD as well as investigation of different stages of dementia (McDermott et al., 2013). Previous studies have either focused only on a single stage or have not defined the severity. The various types of dementia can present and progress differently and as Garrido et al. (2017) suggest: “people with different forms of dementia would not only have different therapeutic needs, but also may respond to music differently” (p. 1130). Whilst it was not possible to have three clearly defined clinical groups representing mild, moderate and severe, the comparison of mild-moderate with severe is still an advantage of this study. Future research should aim to have clearly defined groups with confirmed diagnoses.

This study attempted to deliver all components consistently throughout the sample. However, this was challenging and there was some variation in the delivery within specific components. The motivations for these variations will be discussed further in section 5.5.2. Firstly, baseline and resting periods were intended to be in silence, however many participants, particularly in groups B and C, would talk throughout. The listening components were also intended to be in silence. However, in the FL component several participants responded through movement, began talking and interacting whilst some remained still and in silence. Participants were generally still and silent during the UL component except for group C. In the FS component, some participants sang different songs depending on what was familiar to them. Participant C2 did not sing at all during either singing components. The VI component brought the most variation. Some participants engaged in active improvisation, contributing their own musical ideas, whereas many only copied my vocalisations. On the one hand, this may not represent active improvisation on the participant’s part, however, the music used was still spontaneous and unfamiliar. The DE was adapted for participants with restricted mobility but the same structured elements were retained. For participant C2, however, the DE was an improvised drumming exercise as illustrated in case example 2 (5.3.2). Future research should aim to have sufficient and consistent baseline measures as well ensure that if singing techniques are used that all participants can physically participate.

The chosen parameters offer limited scope for interpretation. Berntson et al. (2007) caution against overinterpreting measures such as RR, which was discussed earlier. Other measures such as tidal volume (the depth of inhalation) and analysis of regularity may have offered more insight, however because of technical difficulties with the RR measurement this would have been unreliable. Similarly to RR, HR is limited as a stand-alone measure of ANS activity. A measure such as HRV may have offered more insight into levels of stress and arousal by indicating the levels of sympathetic-parasympathetic activation, however because of the short duration of the measurement periods as well as the movement, HRV would have been equally susceptible to the technical difficulties experienced (Sheridan et al., 2020). The purpose of multiple physiological measures was to have complementary data that allowed for more interpretation. Had there been fewer technical difficulties, this combination of measures may have offered more insight.

The EEG can be a powerful tool for research, giving insight into neurological activity. However, using only a single channel EEG offers insight into one specific part of the brain. Whilst the prefrontal cortex is an important region to observe with its role in executive function, observation of other important areas involved in musical and social processes such as central regions containing the motor and sensory cortexes, are left out. Comparing results with other electrophysiological studies is therefore challenging as spectral power is generally pooled from all electrode sites to observe overall activity and compare different brain regions. Standard EEG systems use 20 electrodes and in research may even use between 64 and 256 electrodes (Srinivasan, 2007). Future research using a full EEG under the recommended conditions discussed in this section would therefore be beneficial.

The main challenges with the EEG were the conditions of the session. Firstly, EEG is not well-suited to movement, singing, speaking or having the eyes open. Whilst analysis software has become very sophisticated, for example being able to remove eye-blink artefacts, it is not certain whether all were removed. Eye-blinks were removed however artefacts related to body movements were not necessarily removed in this process. Research using EEG where participants are moving, talking or singing appears to be uncommon. Petsche et al. (1988) suggested that researching music performance with EEG may be “impossible” (p.147), because of the problem of artefact. However, small studies have begun to study live instrumental performance. These have been successful as participants were given guidance on minimising movement, sophisticated high-density technology was used, and more thorough and complex artefact removal was done (Limb & Braun, 2008; Lopata et al., 2017; Osaka et al., 2015). Minimising movement was not possible in this study, furthermore a more naturalistic experience of music therapy was desired. Any segments of data considered artefactual are typically rejected from the analysis. However, in this study rejection of artefactual data would have left very little to analyse. Therefore, it was challenging to get accurate results that could be easily interpreted.

There were often technical difficulties with the respiration and HR measurements. For example, movement significantly disrupted the signal of RR recordings (Figure 33) as it interfered with the stretch band around the torso. Some participants had generally artefactual respiration data because of difficulty fitting the band due to larger body size. Therefore, getting accurate values for all participants was challenging. Similar problems occurred with HR monitoring. Participant B8, for example, had no HR data for any of the components as the signal was corrupted.

Figure 33: Participant C1 Interrupted RR signal during movement

The technical difficulties were largely related to the conditions of the study. Controlling elements such as movement, or having the eyes closed would have made many of the components impossible. Therefore, the solution perhaps lies in advancing technology to be able to accommodate unrestricted movement whilst not compromising data quality.

5.5. Challenges of Experimental Music Therapy Research

There is a call for more robust clinical research within music therapy (Downson & McDermott, 2020; McDermott et al., 2013; van der Steen et al., 2018). Existing music therapy research is often criticised for methodological issues such as small sample sizes, lack of standardised outcome measures and diverse MT protocols. The difficulties encountered in this study illustrate some of the challenges associated with designing and executing experimental music therapy research, particularly with a neurophysiological focus. This section will firstly discuss the difficulties associated with protocolising music therapy and acting as both therapist and researcher. Secondly, it will explore how quantitative measurements may not capture the richness and complexity of client experiences. Thirdly, a reflection on the compatibility between music therapy and positivist research will be offered.

5.5.1 Protocolising Music Therapy

Music therapy is a complex intervention. The focus is not on solely administering a musical stimulus, but on the interpersonal relationship that is developed through the musical interactions. This complexity makes experimental clinical research difficult to execute, particularly when in the role of therapist *and* researcher. In order to provide a consistent and replicable intervention, variation has to be minimised. However, in music therapy practice this is challenging as it is a person-centred approach (Bruscia, 2014) where the priority is to meet the client's needs, which may require diversion from the research protocol. The intention of the research was not to offer a session representative of a typical music therapy experience. The focus was on the individual music therapy components in a one-off setting. However, the focus was not purely on the musical stimuli but rather the musical stimuli and techniques in the context of interpersonal interaction.

Had the focus been on purely musical stimuli, participants could have been isolated during the components. The singing components may have been more in a karaoke-style and the drumming instruction perhaps could have been delivered via pre-recorded video instruction. However, results from tightly controlled conditions may be difficult to apply to a music therapy setting and may also be inappropriate for persons with severe dementia. As was observed in participants in group C, therapist intervention strategies were necessary to facilitate or sustain participation. The dynamic and changing interaction between client and therapist and the person-centred approach are essential features of music therapy practice. Removing these in order to isolate the musical elements possibly reduces the relevance of results to clinical practice. This is not to say that tightly controlled experimental approaches that isolate musical elements do not have any relevance for music therapy but rather that these approaches should be complemented by more naturalistic research that incorporates variation in order to assess the ecological validity.

The dual role of therapist and researcher was both advantageous as well as challenging. Being part of the music therapy intervention allowed for deeper insight and observation of participant experiences, which was beneficial in the discussion of case examples. However, these two roles sometimes felt incompatible when trying to act in the interests of the participants' needs whilst also trying to preserve the objectivity of the research. There were several instances of sacrificing participant needs and wants for the benefit of the research. For example, participant C1's musical expression was restricted by telling her to leave the drums alone during the FS component in order to isolate the singing element. There were also instances of sacrificing the consistency of the research for the benefit of participants. For example, in the DE with participant C2 I incorporated voice as it felt clinically appropriate for the very quiet and intimate moment we were having. Her physical limitations also limited her rhythmic abilities, therefore incorporating melody into our playing added richness and meaning to our communication. Whilst the baseline and resting periods were intended to be periods of silence, participants in group C had difficulty understanding this and became restless if sitting in silence. Some participants in group B also began sharing personal stories in the resting periods. Therefore enforcing resting silence felt inappropriate.

5.5.2 Measurement and Analysis

Whilst numeric data has the advantages of offering clear and ‘objective’ answers, in some cases, it may oversimplify a complex human experience. This study produced overall mean values for each component of the session, however reducing a participant’s experience into a single value fails to provide potentially vital details of what occurred. Within a single song or activity there may be shifts and changes, an ebb and flow of engagement, interaction, awareness and emotion. In group C, for example, these shifts and changes were more evident. Maintaining focus on a task was challenging for some participants that would switch between telling a story or being distracted by something in the room, and returning to the music activity when prompted. Music therapy is a complex intervention and the measurement and analysis should take this into account. An approach such as that used by Neugebauer and Aldridge (1998) for example, where HR was analysed in 5-second segments to show time-based and event-related changes may have been beneficial, particularly in the discussion of the case examples.

A challenge faced in this neurophysiological study, where the focus was on internal activity, was not capturing numerically what was observed externally. Participants had contrasting qualities of experience (e.g. someone who was very active, outgoing, interactive and energetic compared to someone who remained still and quiet, less aware and interactive) but there appeared to be little discernible differences in their neurophysiological responses. As discussed in the case examples, there were moments of significance but these could not always be traced in the numerical data. Participant C1, for example, often shifted from distraction and confusion to focus and engagement. However, in these examples the numerical data showed no signs of neurophysiological changes. Whilst it is possible that there simply was very little neurophysiological response for participants, the technical difficulties that were encountered suggest that the results may not truly reflect what was occurring. The possibility for uncovering this activity is restricted by the limitations of current or available technology therefore great care should be taken to select suitable measurement and analysis.

5.5.3 Positivism and Music Therapy Research

Music therapy research situated within a positivist paradigm may risk producing research that loses the essence of person-centred music therapy practice. Bruscia (2005) writes that:

> Positivism provides quantitative researchers with many philosophical comforts. In that world, truth is absolute rather than relative; reality is singular rather than plural; objectivity is attainable rather than delusional. There the purpose of research is clear: to discover and verify what is true and what is not true, based on standardized methods and universal levels of statistical proof. To leave that world of numeric certainty is to embark upon a search for human understanding where there are no reliable maps, no verified routes, and no valid passes. (para. 1)

This is not to say that quantitative research should be avoided. Aldridge (1996) supports the use of both positivist and non-positivist music therapy research as "both poles are necessary to express the life of human beings" (p. 93). Positivistic research has been instrumental in establishing the music therapy profession by providing a wealth of research that could be accepted by the fields of science and medicine (Amir, 1993).

Whilst the focus of this study was on neurophysiological activity, which is quantifiable and measurable, the hope was that it would speak to the rich and complex experiences of music therapy. Therefore, even if this study had produced more statistically significant findings, offering more “numeric certainty” (Bruscia, 2005), without the use of case illustrations and descriptions the richness and value of the participants’ experiences may have been lost. Amir (1993) believes that “those who [analyse] only quantitatively the various elements of music therapy and their effects on the human organism may miss the intrinsic power of music therapy” (p.9). Whilst it is acknowledged that the case descriptions were not intended as a formal source of qualitative data, as no formal method of analysis was used, they allowed for some of the ‘power’ of music therapy to be shown that was not reflected in the neurophysiological results.

Generalisable and robust research is often necessary for motivating for funding and access to therapeutic care. Downson and McDermott (2020) acknowledge that using objective measures to capture musical experience, which is a “multi-faceted phenomenon” (p.175), may seem inappropriate, but it is necessary in order to see if groups of people share the same experience or benefit. Although quantitative research may not tell the whole ‘story’, incorporating qualitative methods, as part of mixed methods approach, may supplement and provide a richer picture of how music therapy works. Therefore a pragmatic stance, where the strengths of both quantitative and qualitative methods are made use of (Onwuegbuzie & Leech, 2005), may be more appropriate for music therapy research.

Chapter 6: Conclusion

6.1 Introduction

This study aimed to answer the primary research question: What are the neurophysiological responses to music therapy components in participants with and without dementia? Heart rate (HR), respiration rate (RR) and EEG power in the prefrontal cortex were measured during a range of receptive and active music therapy techniques with older adults without dementia, with mild to moderate dementia and severe dementia. A descriptive and comparative statistical analysis was carried out in order to compare differences between groups and the various music therapy components. This section will summarise the main findings, review the study's limitations and offer recommendations for further research.

6.2 Summary of Findings

The results revealed a possible trend towards increased HR during active techniques including singing familiar songs, vocal improvisation and structured drumming. Drumming appeared to induce physiological arousal as both HR and RR generally increased. RR was also affected by singing through the musical structure and participant breath control. No statements can be made about the EEG responses, however an unexpected large decrease in Gamma power for participants with severe dementia during structured drumming offers an interesting area of further research as it possibly indicates a change in levels of attention and awareness.

Whilst the results had limited statistical significance this does not diminish the value of what was found. Wasserstein et al. (2019) recommend that researchers should not make conclusions about whether or not results are of practical importance based solely on statistical significance as statistics should not be confused with reality. Instead, they suggest that statistical inference be seen as a "thought experiment" (Wasserstein et al., 2019, p.6). In the reporting and discussion of results, the intention was one of exploration and modesty. Meaning was still found in the statistical analysis, the exploration of observations, and the reflection on the challenges that were faced.

6.3 Limitations

The limitations of this study include its small sample size, lack of control group, technical difficulties with data acquisition and analysis, lack of confirmed dementia diagnoses and the many health conditions and medications for the majority of participants. This research is novel in its use of methods of measurement that are typically not used in conditions such as active music therapy. These conditions created a range of difficulties, however there is great benefit from an attempt being made. The thorough reporting of the process and exploration of the technical and practical challenges are perhaps one of the key contributions of this study to the existing body of research. Interdisciplinary research depends on fields bringing their expertise together. It is important for these fields to have an understanding of one another in order to produce research that is meaningful for all disciplines involved. This study firstly illustrates the shortcomings of technology that are typically reliable in laboratory settings but have limitations in practical and applied settings. It is vital that correct measurements are chosen for the conditions. Secondly, it illustrates the challenges of being both in the role of music therapist and researcher. Thirdly, it shows the unpredictable nature of research in long-term care facilities. Finally, it motivates for the use of mixed methods in music therapy research, where the essence or power of the work may be lost when the story is not told.

6.4 Recommendations for Further Research

A number of recommendations can be made based on this exploratory pilot study. Firstly, this exploration of real-time cardiovascular and respiratory activity during both receptive and active music therapy techniques with persons with varying severities of dementia should be continued using a larger sample, confirmed dementia diagnoses and more robust technology. A greater focus should be placed on persons with late-stage dementia, as the advantage of neurophysiological measurement is the insight into internal processes that may not be externally observable. Exploration of real-time neurophysiological activity during music or music therapy exposure has generally been neglected, particularly in persons with dementia. Whilst EEG research may be the most challenging to carry out in naturalistic settings, should technological advances be made, this may offer the greatest insight into internal experiences.

6.5 Conclusion

This research aimed to explore the internal processes involved in participants' experiences of various music therapy techniques. Whilst these may not have been made as clear as was hoped through the neurophysiological measures that were used, it was nonetheless clear that many participants were moved. As music therapist, Gary Ansdell (1995) writes, "much of the effectiveness of any music therapy stems from the fact that music moves us - physically and emotionally; that it involves us and gives a sense of liveliness" (p.89). In cases where words are unreliable or inaccessible, music becomes a tool for communication and experiencing connection. Music therapy may offer persons with dementia these experiences of communication and connection, which may be generally lacking. Engaging with music in the context of a supportive therapeutic relationship has the capacity to move not only the human body, but also the mind and the spirit.

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Appendices

Appendix A: Example of Session Notes

Participant B5

Timing	Component	Description	Notes/Comments
00:10	Baseline	Bright affect, eyes open, looking around, speaking, appears relaxed.	
02:22	**1: Familiar listening**	immediately begins to move shoulders, head and hands to the music, facial expressions. Light foot tapping (RF) Big smile, speaking to MT. 2:55 begins to sing lyrics, briefly. Smiles and laughs. Bright affect throughout.	
04:46	Rest 1	Bright affect, eyes open, looking around, speaking, appears relaxed.	P asks "Who was the singer?"
06:05	**2: Unfamiliar listening**	Eyes open, fixed gaze, appears relaxed.	
07:50	Rest 2	Bright affect, eyes open, looking around, speaking, appears relaxed.	Repeats phrase "just a few doors down the view is so different" P makes this statement several times throughout the session.
09:00	**3: Familiar Singing**	You Are My Sunshine, Initially 70BPM. P immediately begins to sing the lyrics along with MT. Closes eyes, bright affect. 9:32 variation on groove, P follows MT closely, singing every lyric. 9:54 "lala" P immediately begins to sing on "la" following MT, harmonizing with MT. 10:17 humming, P hums along with MT. 10:40 lyrics again, sings along immediately. Foot tapping and bright affect throughout. 11:05 ritardando ending.	
11:34	Rest 3	Bright affect, eyes open, looking around, 12:25 appears relaxed.	

12:48	**4: Vocal improvisation**	Guitar intro 90BPM. 12:58 MT begins to sing "la", P watches her closely with a bright affect, P begins to hum at 13:03. 13:16 opens her mouth to vocalize with MT briefly, continues to hum. Moving hands and head slightly to the beat throughout. 13:32 begins to sing along following MT. 13:44 begins to anticipate what MT will sing and sings along. 13:48 tempo changes to legato 3/4 73BPM. Smiles at MT and sings along, following closely. 14:12 P begins to harmonize with MT, singing "la". Harmonizing continues until 14:55 when original tempo is reestablished. P moves to the beat again, harmonizes with MT on "la" and improvises independently from MT. 15:34 ritardando, ending together with P harmonizing. Ends with a high note and a big smile 15:38.	
15:47	Rest 4	Bright affect, eyes open, looking around, speaking, appears relaxed.	P says "This is fascinating stuff you do".
17:23	**5: Drumming Exercise**	Initial tempo 100BPM, follows MT RH, LH, BH accurately. 17:53 double time, P follows along. 17:42 MT changes pattern, follows along accurately. 18:01 new pattern, follows along accurately immediately. 18:19 new pattern with clap. P follows immediately. 18:26 new pattern, P follows immediately. 18:36 new pattern with alternating hands, P follows along, slightly hesitates. 18:52 both hands again, P follows. 19:00 MT invites P to create a rhythm pattern. 19:05 begins to drum pattern independently, alternating hands. 19:22 P changes the pattern after MT prompts. 19:45 P creates a new pattern, after MT prompts. 20:02 MT directs back to original pattern with both hands. P follows immediately. 20:10 RH, 20:19 LH, 20:27 BH. P follows all prompts accurately. 20:32 MT counts down to ending.	P says "We are good!"

Appendix B: Letter from statistician

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

DEPARTMENT OF STATISTICS

LETTER OF STATISTICAL SUPPORT

Date: 15 August 2019

This letter is to confirm that **Ms K Farquharson**, studying at the University of Pretoria, discussed the project with the title “**Neurophysiological activity during music therapy with individuals with Alzheimer’s disease**” with me.

I hereby confirm that I am aware of the project and I also undertake to assist with the statistical analysis of the data generated from the project.

The sample will consist of 20 adults who will be assigned to four equal sized groups. Group one will consist of an age-matched healthy comparison group who do not suffer from Alzheimer’s disease. Groups 2 to 4 will each consist of five participants who have been diagnosed with mild, moderate or severe Alzheimer’s disease.

The data analysis will consist of descriptive statistics such as means, standard deviations, quartiles and interquartile range. Since the sample size is small, non-parametric tests will be performed to compare the medians between the four groups (Kruskal-Wallis test) and also within each group to compare the medians of measurements throughout the intervention (Wilcoxon signed rank test).

Ms JC Jordaan
Research consultant
Internal Statistical Consultation Service
Department of Statistics
E-mail address: joyce.jordaan@up.ac.za

Appendix C: Participant Information

FACULTY OF HUMANITIES
DEPARTMENT of MUSIC

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Music Therapy Unit
Tel: 012 420 5372
Fax: 012 420 4517
musictherapy2@up.ac.za

Participant Information

Study title: Neurophysiological activity during music therapy with individuals with dementia

Dear participant,

I am researching the neurophysiological activity that occurs during a music therapy session with adults with and without Alzheimer's disease. This research forms part of my Master's degree in music therapy. The research involves conducting one music therapy session with each participant. During the session I will be measuring neurophysiological activity by using two devices that the participant will wear. One device is a strap that is worn around the chest which will measure heart rate and breathing activity and the other device is a headset that sits on the scalp which reads electrical signals in the brain. I will provide information on how to put these devices on correctly. They cause no pain or discomfort to wear. The heart rate device requires contact with the skin therefore you will be given a moment in private to put the device on yourself or, if necessary, with assistance from a member of care staff.

There are no anticipated risks or harm associated with participation. Participation is voluntary and you have the right to withdraw at any point without consequences. The testing session will last approximately 60 minutes in total.

I will be making use of audio and video recording in sessions. These recordings will be used for research purposes. Visual and audio recordings of sessions are standard practice and privacy and confidentiality will be assured at all times. The data will be archived at the department of music at the University of Pretoria for a minimum of 15 years. It will be possible to arrange to view/listen to the recordings should you so wish. The research findings will be written up in the form of a dissertation to be submitted for my Master's degree. A published journal article will follow this process. These will, of course, be made available to you upon request. No identifying information will be used in any published work.

Please feel free to contact me should you have any questions. Your decision to participate will be greatly appreciated.

Many thanks,

Kate Farquharson
Researcher / Student
Email: katefarquharson@gmail.com
Cell Number: 0718899295

Supervisor
Dr Carol Lotter
Carol.lotter@up.ac.za

Appendix D: Participant consent form

FACULTY OF HUMANITIES
DEPARTMENT of MUSIC

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Music Therapy Unit
Tel: 012 420 5372
Fax: 012 420 4517
musictherapy2@up.ac.za

Participant Consent Form

Date: ……………………………

Name of student: **Kate Farquharson (U18295615)**

Title of study: Neurophysiological activity during music therapy with individuals with dementia

I, ______________________________________ (participant), give my consent to participate in this research study by attending one music therapy session with the abovementioned music therapy student. I understand that I have the personal choice to participate and may withdraw at any stage.

I also grant permission for the session to be recorded onto video and/or tape. I understand that these recordings will be used for research purposes only. I understand that visual and audio recordings of sessions are standard practice. Privacy and confidentiality are assured, in line with professional ethical practice. This material will not be distributed or sold. I understand that I can arrange to view / listen to the recordings should I so wish.

Participant name:___________________________

Signature:_____________________________

Researcher:___________________________

Signature:_____________________________

Supervisor: ___________________________

Signature:___________________________

Appendix E: Proxy consent form

FACULTY OF HUMANITIES
DEPARTMENT of MUSIC

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musictherapy2@up.ac.za

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Proxy Consent Form

Date: ……………………………

Name of student: **Kate Farquharson (U18295615)**

Title of study: Neurophysiological activity during music therapy with individuals with dementia

I give consent for ________________________ (participant name) to participate in this research study by attending one music therapy session with the abovementioned music therapy student. I understand that ______________________ has the personal choice to participate and may withdraw at any stage.

I also grant permission for the session to be recorded onto video and/or tape. I understand that these recordings will be used for research purposes only. I understand that visual and audio recordings of sessions are standard practice. Privacy and confidentiality are assured, in line with professional ethical practice. This material will not be distributed or sold. I understand that I can arrange to view / listen to the recordings should I so wish.

Name of proxy/guardian:____________________________
Signature:____

Researcher signature:_____________________

Supervisor signature:_________________________

Appendix F: Institution consent form

FACULTY OF HUMANITIES
DEPARTMENT of MUSIC

Music Therapy Unit
Tel: 012 420 5372
Fax: 012 420 4517
musictherapy2@up.ac.za

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Institution Permission Form

Institution: Arbor Village – Methodist Homes

Name of student: **Kate Farquharson (U18295615)**

Title of study: Neurophysiological activity during music therapy with individuals with dementia

I, ______________________________________ (institution representative), give my consent for this research to be conducted with residents at Arbor Village. I understand that residents have the personal choice to participate and may withdraw at any stage without having to say why.

I also grant permission for the music therapy sessions to be recorded onto video and/or tape. I understand that these recordings will be used for research purposes only. I understand that visual and audio recordings of sessions are standard practice. Privacy and confidentiality are assured, in line with professional ethical practice. This material will not be distributed or sold. The data will be archived electronically at the department of music at the University of Pretoria on a password protected storage device for a minimum of 15 years. The data may also be used by other researchers for future studies.

Institution Representative

Representative: _______________________ Signature:______________________

Position at institution:__________________

Student & Supervisor

Researcher:__________________ Signature:______________________

Supervisor:__________________________

Appendix G: Participant information

Pt	Sex	Age	ABC Score	Diagnoses	Medication
A1	F	72	NA	None	None
A2	F	78	NA	Hypertension	Antihypertensive (unspecified), Diclofenac sodium
A3	F	68	NA	Hypertension	Indapamide, Ezetimibe
A4	M	70	NA	None	None
A5	F	77	NA	Hypertension	Enalapril Maleate
M = 73 *(SD = 4.4)*					
B1	F	84	95	Hypertension, Depression	Atorvastatin, Perindopril, Trazodone, Brintellex, Venlafaxine
B2	F	75	103	Hypertension, depression,	Atorvastatin, Levothyroxine Sodium, Pantoprazole, Allopurinol
B3	F	85	82	Hypertension	Atorvastatin, Enalapril Maleate, Bisoprolol, Levothyroxine Sodium, Citalopram
B4	M	82	96	Hypertension, Cancer (prostate)	Losartan, Aspirin, Lansoprazole, Etoricoxib, Tamsulosin, Escitalopram
B5	F	81	85	None	Donepezil, Ergocalciferol, Citalopram, Levothyroxine Sodium
B6	F	91	81	Hypertension, Depression	Citalopram, Sulpiride, Zopiclone
B7	F	78	95	Thyroid condition (unspecified), diabetes type 2	Levothyroxine Sodium, Glicazide, Donepezil, Loprazolam, Oxazepam, Risperidone, Sertraline
B8	F	81	68	Hypertension, osteoporosis	Atorvastatin, Perindopril, Esomeprazole
M = 82.1, *SD* = 4.8					
C1	F	79	36	Hypertension, Diabetes (type 2), Alzheimer's disease	Simvastatin, Valsartan, Metformin, Aspirin, Quetiapine
C2	F	69	33	Diabetes (type 1), Asthma, Alzheimer's disease	Insulin, Atorvastatin, Ipratropium Bromide, Montelukast, Donepezil, Quetiapine
C3	F	80	39	Diabetes (type 1), Vascular Dementia	Atorvastatin, Celecoxib, Esomeprazole, Donepezil, Loprazolam, Venlafaxine
C4	F	88	62	Dementia (unspecified)	Atorvastatin, Lamotrigine, Zopiclone, Alprazolam
C5	M	92	46	Hypertension, Dementia (unspecified)	Citalopram, Mirtazapine, Quetiapine, Haloperidol
M = 81.6, *SD* = 8.9					
Total *M* = 79.4, *SD* = 7					

Appendix H: EEG descriptive statistics

BASELINE (uV^2)						
		Gamma	**Alpha**	**Beta**	**Theta**	**Delta**
Group A	M	1.12E-07	1.80E-07	3.84E-07	1.41E-07	1.13E-07
	Mdn	1.12E-07	1.81E-07	3.83E-07	1.42E-07	1.14E-07
	Min	1.10E-07	1.80E-07	3.79E-07	1.37E-07	1.06E-07
	Max	1.14E-07	1.81E-07	3.89E-07	1.44E-07	1.18E-07
	IQR	3.50E-09	1.40E-09	6.25E-09	3.71E-09	8.67E-09
Group B	M	1.10E-07	1.77E-07	3.79E-07	1.38E-07	1.11E-07
	Mdn	1.10E-07	1.77E-07	3.80E-07	1.37E-07	1.10E-07
	Min	1.08E-07	1.70E-07	3.71E-07	1.29E-07	1.02E-07
	Max	1.14E-07	1.86E-07	3.88E-07	1.43E-07	1.23E-07
	IQR	3.67E-09	4.88E-09	1.33E-08	6.10E-09	1.38E-08
Group C	M	1.30E-07	1.82E-07	3.92E-07	1.41E-07	1.16E-07
	Mdn	1.33E-07	1.79E-07	3.89E-07	1.45E-07	1.17E-07
	Min	1.07E-07	1.74E-07	3.83E-07	1.32E-07	1.05E-07
	Max	1.42E-07	1.94E-07	4.02E-07	1.47E-07	1.27E-07
	IQR	2.25E-08	1.34E-08	1.67E-08	1.19E-08	1.42E-08
Overall sample	M	1.16E-07	1.79E-07	3.84E-07	1.40E-07	1.13E-07
	Mdn	1.11E-07	1.80E-07	3.84E-07	1.41E-07	1.13E-07
	Min	1.07E-07	1.70E-07	3.71E-07	1.29E-07	1.02E-07
	Max	1.42E-07	1.94E-07	4.02E-07	1.47E-07	1.27E-07
	IQR	8.96E-09	4.99E-09	8.55E-09	7.02E-09	1.17E-08

COMPONENT 1 - FAMILIAR LISTENING (uV^2)						
		Gamma	**Alpha**	**Beta**	**Theta**	**Delta**
Group A	M	1.12E-07	1.79E-07	3.85E-07	1.38E-07	1.12E-07
	Mdn	1.13E-07	1.80E-07	3.88E-07	1.39E-07	1.14E-07
	Min	1.08E-07	1.72E-07	3.71E-07	1.36E-07	1.05E-07
	Max	1.14E-07	1.82E-07	3.96E-07	1.40E-07	1.17E-07
	IQR	4.50E-09	7.61E-09	1.87E-08	2.55E-09	1.03E-08
Group B	M	1.11E-07	1.77E-07	3.80E-07	1.36E-07	1.12E-07
	Mdn	1.12E-07	1.77E-07	3.80E-07	1.37E-07	1.10E-07
	Min	1.08E-07	1.70E-07	3.70E-07	1.33E-07	1.06E-07
	Max	1.15E-07	1.82E-07	3.90E-07	1.38E-07	1.21E-07
	IQR	3.98E-09	5.28E-09	9.83E-09	2.52E-09	9.33E-09
Group C	M	1.29E-07	1.80E-07	3.84E-07	1.42E-07	1.12E-07
	Mdn	1.34E-07	1.81E-07	3.82E-07	1.41E-07	1.14E-07
	Min	1.06E-07	1.74E-07	3.64E-07	1.36E-07	1.05E-07
	Max	1.37E-07	1.84E-07	3.98E-07	1.48E-07	1.16E-07
	IQR	1.66E-08	5.36E-09	2.15E-08	8.66E-09	9.48E-09
Overall sample	M	1.16E-07	1.78E-07	3.83E-07	1.38E-07	1.12E-07
	Mdn	1.13E-07	1.78E-07	3.82E-07	1.38E-07	1.12E-07
	Min	1.06E-07	1.70E-07	3.64E-07	1.33E-07	1.05E-07
	Max	1.37E-07	1.84E-07	3.98E-07	1.48E-07	1.21E-07
	IQR	9.72E-09	6.44E-09	1.44E-08	3.33E-09	8.48E-09

COMPONENT 2 - UNFAMILIAR LISTENING (uV^2)

		Gamma	Alpha	Beta	Theta	Delta
Group A	M	1.11E-07	1.79E-07	3.86E-07	1.39E-07	1.14E-07
	Mdn	1.11E-07	1.77E-07	3.86E-07	1.39E-07	1.11E-07
	Min	1.07E-07	1.76E-07	3.78E-07	1.34E-07	1.08E-07
	Max	1.14E-07	1.84E-07	3.92E-07	1.45E-07	1.24E-07
	IQR	4.63E-09	6.47E-09	1.22E-08	7.21E-09	1.30E-08
Group B	M	1.10E-07	1.76E-07	3.77E-07	1.39E-07	1.12E-07
	Mdn	1.09E-07	1.75E-07	3.76E-07	1.38E-07	1.11E-07
	Min	1.06E-07	1.66E-07	3.58E-07	1.29E-07	1.06E-07
	Max	1.15E-07	1.92E-07	3.99E-07	1.51E-07	1.23E-07
	IQR	4.16E-09	1.14E-08	1.84E-08	9.90E-09	7.81E-09
Group C	M	1.28E-07	1.78E-07	3.81E-07	1.39E-07	1.16E-07
	Mdn	1.33E-07	1.78E-07	3.84E-07	1.38E-07	1.07E-07
	Min	1.09E-07	1.77E-07	3.67E-07	1.31E-07	1.02E-07
	Max	1.39E-07	1.79E-07	3.98E-07	1.46E-07	1.45E-07
	IQR	2.10E-08	9.58E-10	2.31E-08	1.12E-08	2.73E-08
Overall sample	M	1.15E-07	1.77E-07	3.81E-07	1.39E-07	1.14E-07
	Mdn	1.12E-07	1.77E-07	3.82E-07	1.38E-07	1.11E-07
	Min	1.06E-07	1.66E-07	3.58E-07	1.29E-07	1.02E-07
	Max	1.39E-07	1.92E-07	3.99E-07	1.51E-07	1.45E-07
	IQR	8.39E-09	4.04E-09	1.62E-08	8.55E-09	1.07E-08

COMPONENT 3 - FAMILIAR SINGING (uV^2)

		Gamma	Alpha	Beta	Theta	Delta
Group A	M	1.12E-07	1.65E-07	3.81E-07	1.41E-07	1.17E-07
	Mdn	1.11E-07	1.76E-07	3.81E-07	1.41E-07	1.18E-07
	Min	1.08E-07	1.07E-07	3.72E-07	1.38E-07	1.08E-07
	Max	1.14E-07	1.84E-07	3.96E-07	1.43E-07	1.23E-07
	IQR	3.99E-09	4.09E-08	1.49E-08	3.20E-09	1.09E-08
Group B	M	1.11E-07	1.78E-07	3.80E-07	1.38E-07	1.10E-07
	Mdn	1.11E-07	1.79E-07	3.80E-07	1.38E-07	1.10E-07
	Min	1.07E-07	1.72E-07	3.66E-07	1.31E-07	1.01E-07
	Max	1.16E-07	1.82E-07	3.90E-07	1.45E-07	1.15E-07
	IQR	4.36E-09	6.67E-09	1.33E-08	5.21E-09	3.95E-09
Group C	M	1.31E-07	1.81E-07	3.88E-07	1.41E-07	1.17E-07
	Mdn	1.36E-07	1.82E-07	3.86E-07	1.39E-07	1.17E-07
	Min	1.12E-07	1.75E-07	3.83E-07	1.36E-07	1.07E-07
	Max	1.39E-07	1.85E-07	3.96E-07	1.47E-07	1.25E-07
	IQR	1.43E-08	7.67E-09	1.02E-08	8.47E-09	1.34E-08
Overall sample	M	1.17E-07	1.75E-07	3.83E-07	1.40E-07	1.14E-07
	Mdn	1.12E-07	1.79E-07	3.82E-07	1.39E-07	1.13E-07
	Min	1.07E-07	1.07E-07	3.66E-07	1.31E-07	1.01E-07
	Max	1.39E-07	1.85E-07	3.96E-07	1.47E-07	1.25E-07
	IQR	1.07E-08	7.38E-09	1.39E-08	4.88E-09	9.36E-09

COMPONENT 4 - VOCAL IMPROVISATION (uV^2)

		Gamma	Alpha	Beta	Theta	Delta
Group A	M	1.11E-07	1.81E-07	3.83E-07	1.42E-07	1.14E-07
	Mdn	1.11E-07	1.83E-07	3.81E-07	1.41E-07	1.13E-07
	Min	1.07E-07	1.75E-07	3.70E-07	1.40E-07	1.09E-07
	Max	1.14E-07	1.87E-07	3.92E-07	1.45E-07	1.19E-07
	IQR	5.40E-09	1.05E-08	1.62E-08	4.05E-09	8.41E-09
Group B	M	1.12E-07	1.79E-07	3.83E-07	1.41E-07	1.14E-07
	Mdn	1.11E-07	1.80E-07	3.84E-07	1.41E-07	1.16E-07
	Min	1.10E-07	1.74E-07	3.72E-07	1.38E-07	1.08E-07
	Max	1.14E-07	1.82E-07	3.94E-07	1.45E-07	1.20E-07
	IQR	3.19E-09	4.56E-09	1.05E-08	5.33E-09	8.97E-09
Group C	M	1.29E-07	1.80E-07	3.85E-07	1.43E-07	1.20E-07
	Mdn	1.36E-07	1.82E-07	3.91E-07	1.43E-07	1.20E-07
	Min	1.06E-07	1.72E-07	3.63E-07	1.39E-07	1.12E-07
	Max	1.39E-07	1.87E-07	3.96E-07	1.45E-07	1.29E-07
	IQR	2.04E-08	8.90E-09	2.27E-08	4.58E-09	1.11E-08
Overall sample	M	1.16E-07	1.80E-07	3.84E-07	1.42E-07	1.16E-07
	Mdn	1.12E-07	1.81E-07	3.84E-07	1.42E-07	1.16E-07
	Min	1.06E-07	1.72E-07	3.63E-07	1.38E-07	1.08E-07
	Max	1.39E-07	1.87E-07	3.96E-07	1.45E-07	1.29E-07
	IQR	7.87E-09	6.32E-09	1.24E-08	4.22E-09	9.41E-09

COMPONENT 5 - DRUMMING (uV^2)

		Gamma	Alpha	Beta	Theta	Delta
Group A	M	1.11E-07	1.67E-07	3.86E-07	1.42E-07	1.16E-07
	Mdn	1.11E-07	1.81E-07	3.88E-07	1.41E-07	1.17E-07
	Min	1.09E-07	1.09E-07	3.75E-07	1.39E-07	1.11E-07
	Max	1.14E-07	1.86E-07	3.91E-07	1.47E-07	1.20E-07
	IQR	3.38E-09	4.06E-08	8.23E-09	5.73E-09	5.11E-09
Group B	M	1.11E-07	1.80E-07	3.82E-07	1.41E-07	1.12E-07
	Mdn	1.11E-07	1.81E-07	3.83E-07	1.40E-07	1.11E-07
	Min	1.07E-07	1.73E-07	3.63E-07	1.37E-07	1.07E-07
	Max	1.15E-07	1.87E-07	3.99E-07	1.46E-07	1.17E-07
	IQR	4.86E-09	9.75E-09	1.85E-08	5.15E-09	7.18E-09
Group C	M	1.10E-07	1.79E-07	3.82E-07	1.40E-07	1.14E-07
	Mdn	1.09E-07	1.78E-07	3.81E-07	1.40E-07	1.14E-07
	Min	1.09E-07	1.76E-07	3.73E-07	1.38E-07	1.11E-07
	Max	1.12E-07	1.82E-07	3.89E-07	1.41E-07	1.17E-07
	IQR	2.64E-09	5.16E-09	1.26E-08	2.92E-09	4.75E-09
Overall sample	M	1.11E-07	1.76E-07	3.83E-07	1.41E-07	1.14E-07
	Mdn	1.11E-07	1.80E-07	3.88E-07	1.40E-07	1.14E-07
	Min	1.07E-07	1.09E-07	3.63E-07	1.37E-07	1.07E-07
	Max	1.15E-07	1.87E-07	3.99E-07	1.47E-07	1.20E-07
	IQR	3.40E-09	5.72E-09	1.43E-08	3.64E-09	6.17E-09

OVERALL SESSION AVERAGE (uV^2)						
		Gamma	**Alpha**	**Beta**	**Theta**	**Delta**
Group A	M	1.11E-07	1.80E-07	3.84E-07	1.41E-07	1.14E-07
	Mdn	1.11E-07	1.80E-07	3.84E-07	1.40E-07	1.14E-07
	Min	1.10E-07	1.77E-07	3.78E-07	1.39E-07	1.12E-07
	Max	1.13E-07	1.82E-07	3.91E-07	1.43E-07	1.17E-07
	IQR	2.49E-09	3.45E-09	7.71E-09	2.95E-09	3.65E-09
Group B	M	1.11E-07	1.78E-07	3.80E-07	1.39E-07	1.12E-07
	Mdn	1.10E-07	1.77E-07	3.79E-07	1.38E-07	1.12E-07
	Min	1.09E-07	1.76E-07	3.73E-07	1.38E-07	1.08E-07
	Max	1.13E-07	1.80E-07	3.89E-07	1.40E-07	1.17E-07
	IQR	2.77E-09	4.63E-09	9.18E-09	2.11E-09	4.16E-09
Group C	M	1.27E-07	1.66E-07	3.85E-07	1.48E-07	1.21E-07
	Mdn	1.30E-07	1.81E-07	3.88E-07	1.41E-07	1.17E-07
	Min	1.18E-07	1.08E-07	3.73E-07	1.39E-07	1.12E-07
	Max	1.32E-07	1.81E-07	3.89E-07	1.78E-07	1.42E-07
	IQR	9.73E-09	3.80E-08	9.06E-09	2.07E-08	1.81E-08
Overall sample	M	1.16E-07	1.75E-07	3.83E-07	1.42E-07	1.15E-07
	Mdn	1.12E-07	1.79E-07	3.84E-07	1.40E-07	1.14E-07
	Min	1.09E-07	1.08E-07	3.73E-07	1.38E-07	1.08E-07
	Max	1.32E-07	1.82E-07	3.91E-07	1.78E-07	1.42E-07
	IQR	1.18E-08	4.02E-09	1.02E-08	3.14E-09	4.78E-09