Understanding the Therapeutic Capacities of Music for People with Dementia

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Music is the language of the spirit.

It opens the secret of life, bringing peace, abolishing strife.

— Kahlil Gibran

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Preface

Throughout recorded history, music has been noted for its ability to promote health and well-being, whether accompanying healing rituals or in a 'prescribed' situation, resembling that of medication. For individuals with cognitive or physical impairment, listening to music can foster a sense of familiarity, recover lost cognitive functions, reduce agitation, offset feelings of isolation, enhance social bonds, and ease pain.

Over the past few decades, significant scientific advances have been made in our understanding of the value of music for health and well-being. Measured observations and controlled trials have confirmed that there are cognitive, motor, psychosocial and behavioural benefits of music for individuals with varying pathologies. These effects are especially notable in individuals who are suffering from neurological conditions, such as dementia, Parkinson's disease, stroke and Autism Spectrum Disorder. To date, however, there is little understanding of the set of critical ingredients in music that enable it to deliver such profound benefits.

In this thesis, I will argue that the vast majority of benefits observed from music-based treatments can be traced to seven essential attributes, or *capacities,* of music. A preliminary discussion of these attributes was outlined by Thompson and Schlaug (2015), who noted that music is simultaneously engaging, emotional, physical, personal, social, persuasive and permits synchronisation. Whilst many of these capacities are not exclusive to music, their unique occurrence in music-based treatments provides a powerful therapeutic tool. Based on this understanding, the *Therapeutic Music Capacities Model* (TMCM) is proposed, discussed and evaluated, and constitutes a primary contribution of the thesis. The model describes these capacities of music and illustrates how they interact with specific brain mechanisms to promote health and well-being among individuals with neurological impairment. The TMCM is presented as an evidence-based model that furthers our understanding of the pluralistic nature of music and its profound therapeutic value.

Although the TMCM model can be used to explain the therapeutic effect that music has for a wide range of neurological disorders, the primary focus of this thesis is on how music can be beneficial for dementia. I propose that the TMCM can be used to develop new and effective music-based therapeutic programs that capitalise on employing all seven capacities. Finally, I argue that the model allows for certain capacities of music to be extracted and studied in detail, to further understand how they contribute to optimal functioning.

Evidence for these arguments is deduced in theoretical and empirical chapters. The theoretical body of work that follows is set out to provide a detailed background of the research to date on the therapeutic use of music for neurological disorders. Specifically, I address how this research forms the basis of the TMCM and the mechanisms and effects of each capacity. Firstly, two literature reviews are provided, with the first discussing the therapeutic value of music for a range of neurological disorders and the second focusing on the role of music for the treatment of dementia. Next, two empirical chapters demonstrate the practical application of the TMCM. We first test the use of the TMCM to devise a music-based program for people with dementia, called the *Music Mind and Movement* (MMM) program. Based on observations during this program, I then determine the relative importance of the *emotional* and *personal* capacities of the TMCM in improving autobiographical memory in people with dementia. I conclude by arguing that music is unique in its capacity to interact with brain function, and the widespread use of music-based treatments for neurological conditions may have far-reaching health, economic, and social benefits.

Statement of Originality

I certify that the work presented in this thesis has not previously been submitted in whole or as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research and the preparation of the thesis itself has been appropriately acknowledged.

In addition, I certify that the information sources and literature used are indicated in this thesis. The research presented in this thesis has been approved by the Macquarie University Human Research Ethics Committee (Reference Numbers: 5201700279; 5201700523) and Hunter New England Local Health District Human Research Ethics Committee (LNR/16/HNE/157).

Signature:

Olivia Helen Brancatisano (Student Number:)

26^{th} April 2019

Thesis by Publication

This thesis is written in the "thesis by publication" format. Chapter 1, 3 and 4 (manuscripts 1, 3 and 4) have been written for independent publications in peer-reviewed journals. Chapter 2 (manuscript 2) has been written for a book chapter. As a result, the format of in-text citations and references may vary from chapter to chapter. In addition, tables and figures have been inserted within each chapter. Brief introductions at the beginnings of Chapters 1-4 provide explanations on how the particular chapter contributes to the thesis and how it connects with other chapters. Where applicable, my contributions in the co-authored papers are specified.

Related Presentations

Research reported in Chapter 3 has been presented:

- Brancatisano, O., Baird A. & Thompson, W.F. (2018, July). The ‘Music, Mind and Movement (MMM)’ Program for People with Dementia. Paper presented at the International Conference on Music Perception and Cognition, Sydney, Australia.
- Brancatisano, O., Baird A. & Thompson, W.F. (2018, June). The ‘Music, Mind and Movement (MMM)’ Program for People with Dementia. Paper presented at the Australian Dementia forum, Sydney, Australia.

Research reported in Chapter 4 has been presented:

- Brancatisano, O., Baird, A., & Thompson, W.F. (2017, November). Reminiscence with music produces more smiles than reminiscence with photos in people with Alzheimer’s dementia. Poster session presented at the CCD Annual Workshop, Mercure Resort Hunter Valley Gardens.
- Brancatisano, O., Baird, A., & Thompson, W.F. (2017, October). Smiles are more frequent during autobiographical memories triggered by music than those triggered by photos. Poster session presented at the NHMRC National Institute for Dementia Research, Australian Dementia Forum, Melbourne.
- Brancatisano, O., Baird, A., & Thompson, W.F. (2017, June). Music evoked autobiographical memories in Alzheimer's dementia are associated with a reminiscence bump and smiling. Poster session presented at The Neurosciences and Music - VI, Boston, USA.

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Abstract

Music is unique in its therapeutic value for people with neurological disorders, such as dementia. This thesis proposes and evaluates the Therapeutic Music Capacities Model (TMCM) which posits that seven specific capacities of music make it a uniquely effective therapeutic tool; namely that music is persuasive, engaging, emotional, personal, physical, social and encourages synchronisation. The thesis explores how these seven attributes of music lead to cognitive, psychosocial, behavioural and motor benefits in a specific neurological population, namely people with dementia. Following an overview of the thesis, two detailed review manuscripts are provided. The first review introduces the TMCM and reviews the existing evidence that demonstrates each capacity's role in a wide range of neurological impairments. The second review focuses on the TMCM in people with dementia specifically, such as facilitating memory recall, fluent speech and the restoration of other cognitive and non-cognitive abilities. These reviews are followed by two empirical manuscripts. The first describes the *Music Mind and Movement* (MMM) program which is derived from the TMCM. The MMM program involved seven weekly group sessions in which two groups of ten individuals with mild to moderate dementia participated. Group 1 completed the MMM program first and Group 2 acted as a wait list control receiving standard care for the first 7 weeks, completing the program second. Results indicated that there was an overall decline in cognition as measured by Addenbrooke's Cognition Examination, in the control group who received standard care. In the MMM condition, there was a trend for an increase in cognition and these differences were present in domains of attention and verbal fluency. The second empirical manuscript focusses on the personal and emotional capacity of the TMCM. Positive facial expressions (smiles) were examined to measure objectively the emotional characteristics of music evoked autobiographical memories (MEAMs) in people with Alzheimer's Dementia. The frequency of smiles and memories elicited by 16 famous songs was measured in nine participants with Alzheimer's Dementia and ten healthy elderly. There were no differences in the presence of smiles between healthy elderly and participants with Alzheimer's Dementia during MEAMs. In people with Alzheimer's dementia, there were significantly more smiles during the presence of MEAMs triggered by songs from personally pertinent lifetime periods. Taken together, the findings of this thesis shed new light on the way in which targeted therapeutic uses of music can provide value for cognition and autobiographical memory. Specifically, the seven capacities of music and subsequent TMCM provide a framework for the development and optimisation of future music-based treatments in dementia.

Chapter 1:

Music as a rehabilitative tool in neurological disorders.

This chapter (manuscript 1) reviews current research on the beneficial therapeutic effects of music for individuals with neurological disorders. The chapter emphasises that there are seven distinct capacities of music (as proposed by Thompson & Schlaug, 2015) which are valuable to cognitive, psychosocial, behavioural and motor functioning; namely that music is engaging, emotional, physical, personal, social, persuasive and permits synchronisation. The chapter introduces the formulation of the *Therapeutic Music Capacities Model* (TMCM) which is based upon these seven capacities and reviews the literature surrounding their impact, specifically on symptoms relating to dementia, Parkinson's disease, stroke and Autism Spectrum Disorder. This manuscript was co-authored by Bill Thompson, Amee Baird and myself. As the primary contributor, I conducted the literature review and prepared the first full draft. Bill Thompson and Amee Baird made critical comments, suggestions, and revisions on the manuscript.

This chapter was prepared as:

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Why is Music Therapeutic for Neurological Disorders?

The *Therapeutic Music Capacities Model*

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CHAPTER 1

Abstract

Music has cognitive, psychosocial, behavioural and motor benefits for people with neurological disorders such as dementia, stroke, Parkinson's disease and Autism Spectrum Disorder. Here we discuss seven properties or 'capacities' of music that interact with brain function and contribute to its therapeutic value. Specifically, music is engaging, emotional, physical, personal, social and persuasive, and it promotes synchronisation of movement and speech. We review existing evidence that, when employed separately or in combination, these capacities have reliable benefits for a wide range of neurological impairments. Based on our review, we propose the *Therapeutic Music Capacities Model* (TMCM), which links individual properties of music to mechanisms of recovery, leading to cognitive, psychosocial, behavioural and motor benefits. This model accounts for the profound value that music affords human health and well-being and provides a framework for the development of music-based treatments for neurological disorders.

Key words: neurological disorders, music, therapeutic, emotion, social, cognitive, psychosocial, behavioural, motor.

1. Introduction

There is increasing recognition of the potential of music to improve psychological, motor and behavioural functions in people with neurological disorders. For example, music is frequently used as a catalyst for regaining freedom of motion in people with Parkinson's disease (PD) and fluidity of speech after a stroke. Further, music invites access to memories in people with dementia, and can facilitate emotional connections for people with Autism Spectrum Disorder (ASD). Nevertheless, an understanding of why music instigates such benefits in neurological populations has not yet been crystalised. In the last decade, research has informed our understanding of the neural *mechanisms* essential to the rehabilitative process for recovery of speech, motor, and memory functions when engaging in musical interventions such as singing, dancing, instrument playing or music listening. These mechanisms of action include the priming of neural networks that are shared between music and non-music functions, the activation of the mirror neuron system (MNS), auditory-motor coupling, motivation and reward, and neuroplasticity (Altenmüller & Schlaug, 2015; Merrett, Peretz, & Wilson, 2014).

Research has also focused on describing the *domains* in which music is particularly efficacious therapeutically, including cognitive, emotional, motor, sensory and social domains (e.g., Särkämö, Altenmüller, Rodríguez-Fornells, & Peretz, 2016; Särkämö, Tervaniemi & Huotilainen, 2013). For example, music can improve motor and gait functions in people with stroke and PD, elicit personal memories and associated emotions in people with Alzheimer's dementia (AD) and improve attention and emotional understanding in people with ASD.

Despite concentrated efforts to refine an understanding of the mechanisms and domains associated with music-based treatments, less attention has been directed towards extracting the *capacities* of music that allow these processes to take place. Previous authors have identified attributes of music that have a unique relationship with, and therapeutic value in, health and well-being. MacDonald, Kreutz and Mitchell (2012) identified a number of qualities of music that account for its beneficial impact on health and well-being, and they pointed out that its ubiquity makes it one of the most accessible therapeutic tools available. For example, music induces *physical* engagement, which is a fundamental goal of neurorehabilitation. It can also be used to *communicate,* and hence enhances *social connections*. These and other properties ultimately impact upon behaviour, emotion, cognition and identity. Altenmüller and Schlaug (2013) pin-pointed some of the capacities of music that are most relevant to neurorehabilitation, such as its ability to elicit motion and emotion, as well as being enjoyable and engaging. Within the field of Music Therapy, there has been extensive development throughout this century of several models and approaches which are utilised when practicing as a Therapist, for example Nordoff-Robbins Music Therapy and The Bonny Method of Guided Imagery and Music. Bonde (2011) presented a model of 'Health Music(k)ing' which aims to incorporate the multiple contexts in which music can promote healing. It includes, but is not limited to, the way in which individuals might *experience* music in a health context (e.g., physiological or psychological, emotional or relational) and the varying *contexts* of health promotion (e.g., pain regulation, and neurological functions). However, these models and approaches lack specificity, both in terms of underlying mechanisms and active ingredients that lead to tangible benefits.

By focusing on known mechanisms of neurorehabilitation, Thompson and Schlaug (2015) identified the seven most significant capacities or affordances that contribute to the health benefits of music in a neurological context. Specifically, music is engaging, emotional, physical, personal, social and persuasive, and it promotes synchronisation of movement and speech. These seven capacities have concrete benefits that are overlapping and interdependent, and the combined outcome of these attributes make music a particularly unique and valuable tool for therapeutic purposes. Although these attributes typically occur simultaneously during rehabilitative music engagement, treatments may also emphasise individual capacities to target specific neurological challenges.

Here, we outline the *Therapeutic Music Capacities Model* (TMCM), which describes the core active ingredients and domains in which beneficial outcomes occur (see Figure 1). The goal of developing such a model is to demystify the *why* of the benefits of music therapeutically. The model provides a framework that identifies the key qualities of music that may account primarily for its therapeutic value and connect these to the therapeutic contexts, mechanisms and outcomes. Although the list is not exhaustive, most therapeutic outcomes derived from music-based treatments can be traced to one or more of these qualities of music. The model we propose outlines the seven capacities of music and their therapeutic benefits. It also contains hypothesised mechanisms, based on the existing literature, indicating how these capacities interact and mutually support one another. The capacities have individual and combined effects, and multiple capacities typically co-occur; this co-occurrence of benefits is the unique power of music. For example, the *physical* and *synchronous* nature of music come together in rhythmic auditory stimulation to both motivate and sustain movement for people with PD. Although each of the seven capacities may lead to distinctive benefits, they overlap in important ways that allow them to combine naturally with one another. In particular, all capacities are associated with enhanced motivation, enjoyment and reward, such that combining multiple capacities in the form of music leads to a convergence of experience and a powerfully effective intervention. The TMCM dissects seven capacities that contribute to music's unique therapeutic value, and provides a novel account of their individual and combined benefits.

CHAPTER 1

The purpose of this review is to describe these seven capacities of music and propose the TMCM. The TMCM first identifies the contexts in which we experience music in a therapeutic way. ‘Music Therapy’ is an evidence-based practice in which a qualified Music Therapist uses music to respond to a client’s psychological needs. ‘Music based treatments’ also require a facilitator, but they are not explicitly trained as a Music Therapist or a trained musician. These facilitators maximise the beneficial interactions with music, for example by selecting appropriate music and activities. The ‘everyday use of music’ involves listening to preferred music, with the involvement of a facilitator being optional. This approach can also be effective for some individuals as it is extremely personalised. However, unless the therapeutic goals are explicitly understood and desired, the potential of music to be maximally effective under such informal contexts may be reduced. The therapeutic context can be experienced as either receptive (listening to music) or active (making music, such as singing or playing an instrument). The TMCM then presents the seven capacities of music that occur in these music-based treatments. We describe neurological and psychological processes that account for the link between the seven capacities of music and their beneficial outcomes. Such outcomes including behavioural, psychosocial, cognitive and motor benefits. Empirical evidence is described that support the therapeutic significance of these seven capacities of music for neurological disorders, specifically dementia, PD, stroke and ASD.

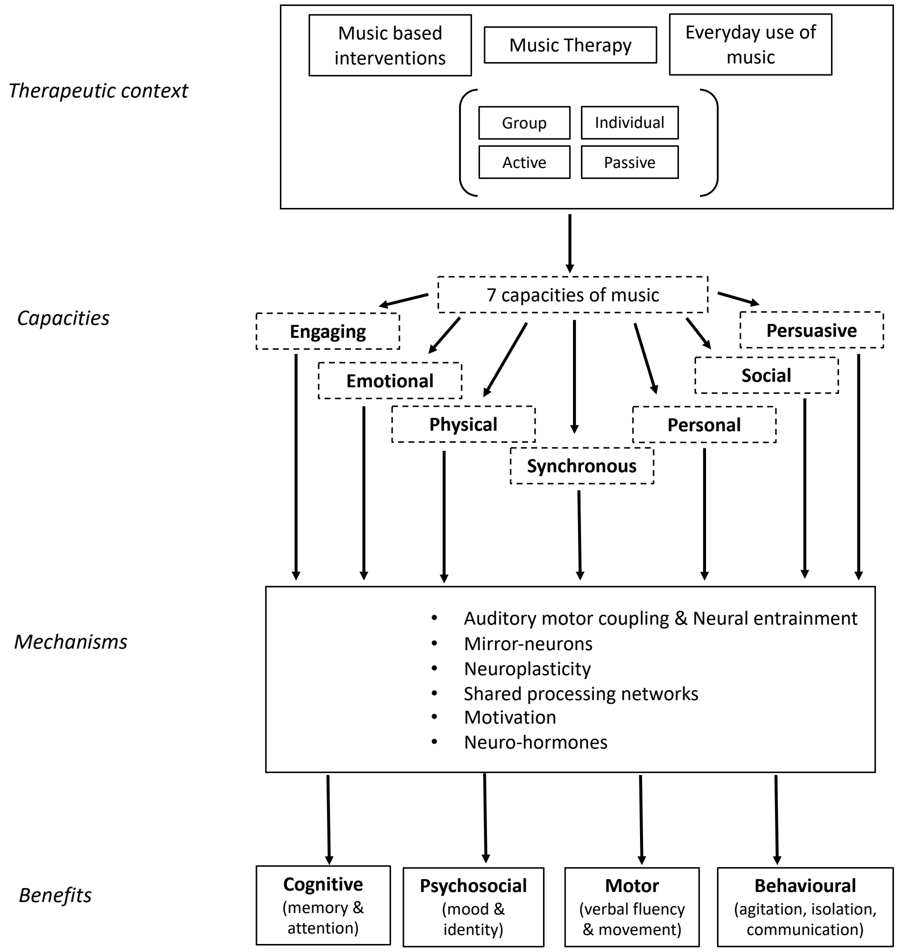

Figure 1. The Therapeutic Music Capacities Model (TMCM)

2. The seven capacities of music

2.1. Music is *engaging*

The engaging nature of music covers both a breadth and depth of processing within the brain. Music engages a broad range of psychological functions (such as attention, learning, memory, emotion, auditory scene analysis, planning and expectation), along with behavioural and physiological functions (such as motor responses, breathing and heart rate). It draws our attention towards a task or stimulus through its combination of abstract features, such as harmony, tempo, timbre, meter, phrasing, dynamics, figure and ground, which our brain is constantly attempting to perceive and track. Music also engages multiple regions of our brain, from frontal, parietal, temporal and cerebellar to deeper limbic structures (Zatorre & Salimpoor, 2013). By engaging multiple processes simultaneously, it places the brain in an 'enriched' and challenging setting, which can stimulate neuroplasticity (Altenmüller & Schlaug, 2015).

Environmental enrichment is a therapeutic strategy that has the potential to initiate the processes of neural plasticity whereby an individual is involved in multisensory, cognitive, and motor tasks that push normal capabilities. Music is a particularly beneficial form of environmental enrichment given its multisensory nature and its capacity to engage numerous brain regions simultaneously. Several processing differences have been observed between musicians and non-musicians, which are suggestive of the advantages of participating in intensive musical activities over a period of time. For example, young musicians have been shown to perform significantly better in the following tasks: auditory, vocabulary, abstract reasoning, mathematical and motor tasks (Schlaug, Norton, Overy & Winner, 2005). Structural differences have also been observed between musicians and non-musicians, indicative of brain plasticity. String musicians have been shown to have larger somatosensory representations of the fingers they use when playing their instruments (Pantev, Engelien, Candia & Elbert, 2001). Further, grey matter volume in areas such as the primary motor, premotor and somatosensory areas and cerebellum has been positively correlated with musicians' status, whereby grey matter volume is highest in professional musicians followed by amateur musicians, then by non-musicians (Gaser & Schlaug, 2003a, b). These structural effects are found well into later life with older practicing musicians reported as having a larger volume of grey matter in the left inferior frontal gyrus compared to that of matched non-musicians (Sluming et al., 2002). There are also cognitive benefits which pertain to those who do not have musical training but musical experience through time spent listening to music, which are explained by the ‘OPERA hypothesis’ (Patel, 2011). The principles outlined in this hypothesis can be adapted to account for the capacity of music to engage listeners and multiple cognitive functions. Specifically, brain responses to music *Overlap* multiple non-musical domains and functions, music requires *Precision* of processing (high demands) and in so doing challenges cognitive functions, music is *Emotionally* rewarding and hence encourages deep processing, music is *Repetitive* and therefore persistently engages the same functions in the brain, and music encourages high levels of *Attention*, which further deepen levels of engagement. Thus, music making and music listening offer an effective form of environmental enrichment for the aging brain and individuals who are recovering from stroke (Särkämö et al., 2008, 2010, 2014; Wan & Schlaug, 2010).

Indeed, specific music training programs have been developed for older adults to prevent the decline in brain functioning that typically arises in aging as a result of age associated disuse (Bugos & Kochar, 2017; Mahncke, Bronstone & Merzenich, 2006; Seinfeld, Figueroa, Ortiz-Gil & Sanchez-Vives, 2013). Bugos, Perlstein, McCrae, Brophy & Bedenbaugh (2007) devised a program in which 31 musically naïve elderly individuals (60–85 years) participated in either six months of piano lessons (one 30- minute lesson and three hours of individual practice per week) or received no training. The individuals who received the musical training improved significantly in their performance of working memory, perceptual speed, and motor skills, with no improvements in those who did not receive training.

The therapeutic benefits of environmental enrichment through music have also been used to regain cognitive function in individuals after stroke. Särkämö et al. (2008 , 2010, 2014) investigated the effect of daily listening to preferred music, versus preferred audio-books, on the acute stages of the recovery period post a middle cerebral artery stroke. They compared three interventions over six months; music (daily listening to self-selected songs), audio books (daily listening to self-selected audiobooks), and standard care (control group). Greater improvements in verbal memory and focused attention were evident after music listening, compared to the audio-books and control condition. In a follow up study, Särkämö et al. (2014) examined the neural correlates of these benefits. They found that the music group showed a greater increase in grey matter volume in the fronto-limbic areas, which supported the behavioural improvement in cognition in their 2008 study. These findings suggest that the capacity of music to engage whole brain networks provides a form of environmental enrichment, which allows for structural reorganisation in the brain of individuals recovering from stroke.

The *engaging* nature of music can be beneficial for a range of neurological conditions. As mentioned above, it can help reactivate cognitive-motor functions in people with dementia and can assist recovery from acquired brain injury by stimulating damaged functions. It is also able to promote social communication and controlled behaviour, for example in individuals with ASD. In particular, music can be utilised to sustain attention during task completion and enhance verbal communication in children with ASD through the activation of shared domains in the brain, namely the MNS (for review see Wan, Demaine, Zipse, Norton & Schlaug, 2010). ASD is characterised by deficits in two areas of functioning: social communication and interaction, and repetitive or restricted behaviours (DSM-V, American Psychiatric Association, 2013). Some of the hallmark features of these deficits include impairments in attention and communication (e.g., Allen & Courchesne, 2001). For example, individuals with ASD may show difficulties in changing their attention between visual tasks (Landry & Bryson, 2004) and attending to social stimuli (e.g., expressions of distress, Dawson, Webb, Carver, Panagiotides & McPartland, 2004). These dysfunctional processes may have direct implications on everyday interactions in a social context. A deficit in the MNS of people with ASD may account for such dysfunction in areas of communication and language (e.g., Hadjikhani, 2007).

Interestingly, individuals with ASD often prefer musical stimuli compared with other types of stimuli, such as verbal stimuli (Blackstock, 1978; Buday, 1995). In some cases, they show superior musical skills which contrasts with their impairment in emotional and communicational domains (Applebaum, Egel, Koegel & Imhoff, 1979; Bonnel et al., 2003; Heaton, 2005, Heaton, Hudry, Ludlow & Hill, 2008). Additionally, compared with neurotypical children, those with ASD attend to music for longer (Thaut, 1987). This interest in music has been harnessed to maximise learning in children with ASD. For example, children are better able to remember words when they are verbally paired with a melody and rhythm (Thaut, 1987). Additionally, the use of music in a therapeutic context facilitates attention and on-task behaviour compared to contexts without music (e.g., Francis, 2011). Simpson, Keen and Lamb (2013) compared the engaging effect of sung conditions with spoken conditions on a language task in children with ASD. The children were asked to listen to contextual sentences and label the names of garden creatures. In the sung condition, the sentences were to the tune of ‘Twinkle Twinkle’. The time engaged in the task was increased during the sung condition compared to the spoken condition. Further, these levels of engagement translated to improvements in learning. Therefore, encouraging sustained attention through music allows individuals to receive the maximum benefits from therapy.

Through the TMCM and examples above, we can see that music’s facility to engage us, through maintaining attention and guiding focus, can improve behavioural, cognitive and motor responses in people with ASD, cognitive decline and stroke. This process can occur through shared processing networks and neuroplastic changes (Figure 1).

2.2. Music is *emotional*

One of the most recognised capacities of music is its ability to reflect and induce emotion. Given that music consists of ‘abstract sounds’, considerable attention has been paid to the mechanisms that may underlie this capacity (Juslin, Barradas & Eerola, 2015). Extrinsic cues, such as the elicitation of visual imagery or autobiographical memories through music, and intrinsic cues, such as expectancy, tension and brain stem reflexes, interact to alter our emotional state (Sloboda & O'Neill, 2001). Music-induced emotions can result in changes in the autonomic nervous system such as an increase in heart rate and respiration (e.g., Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011) and the production of ‘chills’, likened to the sensation of goose-bumps (e.g., Goldstein, 1980; Blood & Zatorre, 2001). Listening to pleasurable music can also lead to an increase in the level of dopamine in the nucleus accumbens (Salimpoor et al., 2011), a response that also occurs for biologically rewarding stimuli such as food and drugs (Schilström, Svensson, Svensson & Nomikos,1998). The combination of musical features, such as pitch, loudness and rhythm can induce heightened emotional states, arousal, motivation and reward (for review see Thompson & Quinto, 2011). These emotional states have the potential to promote immediate and lasting therapeutic benefits, as they are essential for neuroplastic changes (Altenmüller & Schlaug, 2015; Schlaug, 2015; Wan & Schlaug, 2010; Wan, Zheng, Marchina, Norton, & Schlaug, 2014).

Models of the mechanisms by which music induces emotional states may help to account for some of the therapeutic benefits of music. Juslin and colleagues proposed the BRECVEMA framework, featuring eight mechanisms that are said to account for emotional responses to music: *B*rain stem reflexes, *R*hythmic entrainment, *E*valuative conditioning, *C*ontagion, *V*isual imagery, *E*pisodic memory, *M*usical expectancy and *A*esthetic judgement (for detailed descriptions of each see Juslin, 2013; Juslin, Liljeström, Västfjäll & Lundqvist, 2010; Juslin & Västfjäll, 2008). Contagion and episodic memory are among the most commonly occurring emotion-inducing mechanisms in day-to-day life (Juslin & Västfjäll, 2008; Juslin & Sloboda, 2011). The mechanism 'Contagion' reflects how music is able to instil the same emotion in an individual as is being expressed in the music (Lundqvist, Carlsson, Hilmersson & Juslin, 2008). The mechanism 'Episodic memory' refers to the process by which an emotion is induced in an individual as a by-product of the music triggering a memory (Juslin & Västfjäll, 2008). These two mechanisms are especially relevant to treatments of ASD and AD respectively.

The instinctive ability to 'catch' emotions from music has been utilised to interpret emotional cues in social contexts in children with ASD. The MNS of people with ASD is hypothesised to be dysfunctional, accounting for the deficits in communication, language and *Theory of Mind* (the ability to understand the mental states, emotions, intents and beliefs of other individuals) (Baron-Cohen, 1991; Dapretto et al., 2006). Children with ASD have been shown to sustain deficits in certain aspects of emotional processing, namely impaired detection of emotion expression in faces (e.g., Boraston, Blakemore, Chilvers & Skuse, 2007; Sato et al., 2017; Wallace, Coleman, & Bailey, 2008a, b) and voice (e.g., Philip et al., 2010; Rosenblau, Kliemann, Dziobek & Heekeren, 2017; Taylor, Maybery, Grayndler, Whitehouse, 2015), though some studies have suggested otherwise (for a meta-analysis see Uljarevic & Hamilton, 2013). This deficit can result in poor social engagement with other individuals, including rejection and isolation from peers, ultimately leading to loneliness (Bauminger & Kasari, 2000).

Despite emotion processing deficits, children and adults with ASD are able to successfully identify the emotions expressed in music to the same level as age matched controls (Allen, Hill & Heaton, 2009; Caria, Venuti & de Falco, 2011; Gebauer, Skewes, Westphael, Heaton & Vuust, 2014; Heaton, Hermelin & Pring, 1999; Heaton et al., 2008; Quintin, Bhatara, Poissant, Fombonne & Levitin, 2011). Furthermore, their physiological and neural processing responses indicative of feeling emotions from music (e.g., limbic, paralimbic and reward areas, for review see Koelsch, 2010, 2011) have both been shown to be intact (Allen, Davis & Hill, 2013) and similar to neurotypicals (Gebauer, Skewes, Westphael, Heaton & Vuust, 2014). One therapeutic technique that draws from this is the pairing of background music that emphasises a certain emotion such as happiness, with a story created to explain social situations (Ziv & Goshen, 2006; Katagari, 2009). Katagiri (2009) compared the learning of four emotions (happiness, sadness, anger and fear) in several treatment programs: no contact control (no purposeful teaching), contact control (taught with verbal instructions), background music (improvised on piano or recorded matching the emotion) or singing (children's songs sung between child and therapist matching the emotion). All children improved in their emotional understanding, but the background music and singing conditions resulted in greater benefits. Further, the background music had a superior effect on decoding angry emotional cues.

These therapeutic outcomes may be explained by the similarities in acoustic patterns in music and emotional speech (e.g., Juslin & Laukka, 2003). The similarities lead the listener to 'catch' the perceived emotion internally and as a result, perceive emotional cues more easily. The neural foundation of this therapeutic effect may lie in the mediation of the MNS, as the emotional capacity of music may activate the MNS in individuals with ASD (Molnar-Szakacs et al., 2009). Mirror neurons are discharged in the area F5 of the premotor cortex, not only when an action is being performed, but also when that action is being observed; a finding originally observed in the macaque monkey (Rizzolatti & Craighero, 2004; Di Pellegrino, Fadiga, Fogassi, Gallese & Rizzolatti, 1992). The same system has been suggested to exist in the human brain. Music making, listening and imagining is able to engage regions of the brain that overlap with the putative MNS (e.g., Wan et al., 2011; Wan, Demaine, Zipse, Norton & Schlaug, 2010). This emotional nature of music makes it a unique therapeutic tool for communication difficulties in people with ASD.

We can also harness the emotional nature of music for enhancing mood via autobiographical memory in AD (for review, see Särkämö, 2017). It is important to note that the majority of research on music, emotion and dementia has been conducted in individuals with AD. These individuals show intact processing of musical emotions compared to other types of dementia, such as semantic dementia and behavioural variant frontotemporal dementia, a group known as the frontotemporal lobar degenerations (Hsieh, Hornberger, Piguet & Hodges, 2012; Omar et al., 2011). The recognition of musical emotions is spared in AD, but may be impaired in recognition of emotions from facial cues (Drapeau, Gosselin, Gagnon, Peretz & Lorrain, 2009). Further, people with AD demonstrate a comparable ability to healthy individuals in using musical elements such as tempo and mode, to interpret musical emotions (Gagnon, Peretz & Fülöp, 2009). This supports the emotional function of music in dementia care, particularly in AD. Juslin and colleagues consider that music induces emotion through the evoking of autobiographical memories. Hearing a piece of music often brings back memories of a period of life, which subsequently carries the emotion experienced at that time. Episodic or autobiographical memories that are triggered by music contain more emotional content and are more positively valenced than episodic memories evoked in silence (El Haj, Fasotti & Allain, 2012; Cuddy, Sikka, Silveira, Bai, & Vanstone, 2017).

Cuddy et al. (2017) studied the production of memories evoked by instrumental music. They found that compared to younger adults, older adults with AD produced memories with greater positive content and also self-rated these memories as more positive and less negative. This finding is known as the 'positivity effect' which explains how with age, adults become more positive about life. Cuddy and colleagues' (2017) findings suggest that music is particularly effective at enabling this. To explain this from a structural point of view, the medial frontal and limbic areas are relatively spared from degeneration in AD (Jacobsen et al., 2015). These essential memory areas are highly responsive to music and, as such, triggering these memories is an automatic process that is not dependent on such functions as attention and executive control that may be subject to decline in AD (El Haj et al., 2012). Taken together, these results imply that the induction of emotion through episodic memories triggered by music can advantage people with AD by facilitating a positive state of mind.

One further way in which the emotional nature of music can afford therapeutic benefit is through modulating attention in unilateral neglect after right hemisphere stroke. The implication of unilateral neglect is the impairment in orientating towards stimuli located on the contralesional side of the brain lesion in the patient. As mentioned above, music is particularly effective in inducing emotion, and as such has been studied to determine whether it can reduce the effects of neglect by modulating one's emotional state. Pleasant music has been shown to improve recovery in attention, verbal memory and the emotional domain in individuals recovering from stroke (Forsblom, Laitinen, Särkämö & Tervaniemi, 2009; Särkämö et al., 2008). This effect may be accounted for by the increase in an individual's level of arousal and mood, known as the arousal-mood-hypothesis (Schellenberg, Nakata, Hunter & Tamoto, 2007; Thompson, Schellenberg, & Husain, 2001).

Soto et al., (2009) applied this understanding to determine whether inducing positive emotional states using pleasant music would enhance visual awareness in patients with chronic visual neglect. In a within-subjects design, three participants listened to their pleasant preferred music, or un-preferred music, or underwent a period of silence while performing visual search tasks. Visual awareness was improved when listening to the pleasant music compared to listening to the un-preferred music or under silent conditions. Further, enhanced activity was observed through Functional Magnetic Resonance Imaging (fMRI) during the preferred music condition in areas associated with emotion, namely the orbitofrontal cortex and the cingulate gyrus. Similar studies have replicated these effects, showing the amelioration of visual neglect after listening to classical music (Tsai et al., 2013) and pleasant music (Chen, Tsai, Huang & Lin, 2013). Chen et al., (2013) observed that listening to pleasant music as opposed to unpleasant music, of any genre, or silence resulted in an improvement in visual search tasks pertaining to the contralesional targets, which was corroborated by the facilitation of left eye movements as well as more positive mood and arousal. Tsai et al. (2013) compared listening to classical music, white noise or silence, and showed an improvement in participants' performance on line bisection and object reporting tasks in the classical music condition. Self-report data also showed a high level of enjoyment in the classical music condition and participants indicated that they would be willing to participate in the intervention again. Thus, the positive emotions experienced in response to pleasant music heighten arousal and increase neural activity, which may lead to the recruitment of other available neural resources in the damaged hemisphere of these patients (Soto et al., 2009, see Figure 1).

These examples contribute to our understanding of how music's underlying capacity to induce emotions can be utlilised to promote behavioural outcomes such as social functioning in children with ASD and psychosocial and cognitive outcomes in people with AD, as suggested by the TMCM.

2.3. Music is *physical*

CHAPTER 1

Music stimulates spontaneous physical movement, encouraging transition from a state of stillness to synchronised movement that ranges from tapping one's foot to dancing. In many cultures, music and dance are defined by one word encompassing both (Merker, 1999; Nettl, 2000). It could be argued that movement is an inherent component of most music, given that motor areas within the brain are recruited whenever we listen to rhythmical music, even when no movement is generated (e.g., Chen, Penhune & Zatorre, 2008; Grahn & Brett, 2007; Grahn, 2012; Merchant et al., 2015). The significance of music induced physical movement in neurological disorders has been amply demonstrated. Dance provides significantly greater protective benefits than physical exercise alone in non-neurological populations, both cognitively and physically (Verghese et al., 2003; Verghese 2006). Further, dance has promising therapeutic benefits for improving symptoms of PD such as gait, balance and mobility (for a review see Shanahan, Morris, Bhriain, Saunders & Clifford, 2015).

Research suggests that engaging in physical exercise may reduce the risk of certain neurological impairment, such as aged-related cognitive decline (Larson et al., 2006; Hamer & Chida, 2009; Sofi et al., 2011; Buchman et al., 2012), and the onset of PD (Xu et al., 2010) and stroke (Lee, Folsom & Blair, 2003). For older adults without neurological disorders, these findings underscore the importance of engaging in physical activity as a way of decreasing these risks. However, older adults do not always find engaging in physical activity an enjoyable task. Pairing exercise with music through dance is more motivating than exercise in the absence of such music (Jacobson, McKinley, Leroux & Rainville, 2005). In a prospective cohort of 469 participants over the age of 75 years old, the risk of developing dementia was found to be reduced in older adults who engaged in dance on a regular basis, compared to those who rarely or never danced (Verghese et al., 2003). Furthermore, in this study the only physical activity associated with a lower risk of dementia was dancing, out of a range of other activities such as individual exercise (e.g., swimming, bicycling, walking) group exercises, housework and babysitting. Verghese (2006) also examined the physical benefits in 24 older adults who regularly engaged in different types of social dancing, such as ballroom dancing, line dancing, swing dancing and square dancing, compared to 84 older adults who engaged in other physical activities but not social dancing. Several physical benefits were observed in the older adults who participated in social dancing compared to those that did not, such as better balance and longer strides, indicative of a more stable walking pattern. The study also reported a lower prevalence of falls in the older adults who participated in social dancing. However, this was not significant due to the small sample.

Dance plays an important role in regaining the flow of movement in people with PD. Degeneration of dopaminergic cells in the basal ganglia, as a result of PD, causes dysfunction in the initiation and timing of motor sequences, leading to falls and a decreased sense of well-being (Michałowska, Fiszer, Krygowska-Wajs & Owczarek, 2005; Grimbergen, Schrag, Mazibrada, Borm & Bloem, 2013). In these individuals, dance is often used as a successful intervention in overcoming gait impairment and the slowing of movements. It has been shown to offer further physical benefits, such as balance and functional mobility, compared to exercise alone (Hackney, Kantorovich, Levin & Earhart, 2007). A meta-analysis was conducted by Shanahan et al. (2015) to assess the effectiveness of a variety of dance interventions, such as the Tango, Waltz/Foxtrot, contact Improvisation and Irish dancing, for movement problems in individuals with PD. High quality evidence, involving multiple randomised control trials, supported the Tango as an effective form of treatment for PD, improving balance, mobility and endurance (e.g., Hackney et al., 2007; Hackney & Earhart, 2009; Duncan & Earhart, 2012). There was sparse, lower-quality evidence to suggest the beneficial effect of other dance styles for PD, such as Irish dancing (Volpe, Signorini, Marchetto, Lynch & Morris, 2013). One study in particular compared the benefits for movement control from participating in either a Waltz/Foxtrot or Tango intervention (Hackney & Earhart, 2009). Participants in either of the two dance styles improved balance, walking distance, gait and locomotion whereas the locomotion and disease severity of those in the control condition, receiving no intervention, worsened significantly. The Tango afforded further benefits in reducing freezing of gait compared to the Waltz/Foxtrot.

One underlying mechanism responsible for these advantages of the Tango in people with PD may be the external cueing of compensatory mechanisms through music. The music and rhythm may activate movement via shared non-damaged networks, such as the supplementary motor area, premotor cortex and cerebellum (Figure 1) (for review see Koshimori & Thaut, 2018). Further, from a musical standpoint, the tango consists of variations in rhythm and speed prompting slow and quick steps. This correspondingly involves the participant in controlling their movements, particularly stepping speed and size. Thus, the music matches with the momentum and initiation of physical movements.

Taken together, the therapeutic significance of the physical nature of music is evident, not only in the way music can encourage physical movement, thereby promoting cognitive and physical health, but also in the way music-induced movement enhances motor fluency in people with PD, as outlined in the TMCM.

2.4. Music permits *synchronisation*

Whilst the capacity of music to encourage movement affords health benefits, moving *in time* to music yields benefits of its own. Musical elements such as rhythm and melody afford synchronisation through singing or moving, promoting fluency of speech and motor functions. A unique feature that distinguishes musical activities from other social behavior is the externalisation of predictable rhythms that allow synchronisation to occur between two or more people (e.g., Bispham, 2006; Merker, Madison, & Eckerdal, 2009). The affordance of synchronisation is harnessed in treatments for neurological disorders that affect motor responses, aiding in the initiation and coordination of movement and speech (Wan, Ruber, Hohmann & Schlaug, 2010; Wan, Ruber, Hohmann & Schlaug, 2010). The process of synchronising gait with a regular beat has been shown to help people with PD to initiate and continue lower limb movement (Lim et al., 2005). Further, patients time their speech by vocalising words that have been set to melodic and rhythmic phrases, which are used to facilitate speech recovery in stroke and overcome language difficulties in ASD (for review see Schlaug, 2015).

The benefits of pairing speech with melodic and rhythmic contexts have been especially exploited in the well-established practice Melodic Intonation Therapy (MIT). MIT involves pairing left hand tapping movements with regular rhythmic cues and intoning words to pitch cues (Norton, Zipse, Marchina, & Schlaug, 2009). It is used predominantly in patients with non-fluent aphasia, or impaired expressive language, due to a stroke damaging Broca's area in the left frontal region. The melodic and rhythmic components of MIT have been shown to engage bi-lateral homologous regions in the right hemisphere, laying down a new pathway for speech production and bypassing the damaged left hemisphere (Schlaug, Marchina, & Norton, 2009; Zipse, Norton, Marchina, & Schlaug, 2012). The left hand tapping serves as an external metronome by providing a steady rhythm, and facilitates speech production through coupling motor and auditory systems (Norton et al., 2009). A proposed underlying mechanism is that synchronising words and phrases with the melodic intoning may help by allowing slower articulation of the words or by providing an additional aid for memory encoding and access (Wilson, Parsons, & Reutens, 2006).

Auditory-Motor Mapping Training, a modification of MIT, has been developed by Schlaug and colleagues to assist speech in children with ASD who are minimally verbal, or non-verbal. Significant improvements have been demonstrated in the articulation of words and phrases (Wan et al., 2011), and the pronunciation of syllables, consonants and vowels (Chenausky, Norton, Tager-Flusberg & Schlaug, 2016). In this technique the synchronisation of the motor response (tapping) is said to prime sensorimotor networks that control articulatory speech movements (e.g., Bangert et al., 2006; Dambeck et al., 2006).

Rhythmic auditory stimulation (RAS) is another clinical technique that has been used for people with PD as a way of facilitating smoother gait by using a steady beat, such as a metronome, to entrain walking speed (for a review see Francois, Grau-Sanchez, Duarte, & Rodriguez-Fornells, 2015). Studies have shown that this technique enables improvement in length of stride, gait velocity, and step cadence (Thaut et al., 1996) and freezing of gait (for review, see Nombela, Hughes, Owen, & Grahn, 2013). When comparing RAS to other treatments, such as visual cues using stripes on a floor, it seems that presenting auditory rhythmic cues is more effective (Nombela et al., 2013). One hypothesis is that the steady rhythm helps by providing an external cue for movement, re-routing this problem around the basal ganglia to the brain stem (Fernandez del Olmo & Cudeiro, 2003). This synchronisation of bodily movements to an external beat is an instinctive human action that is strongly associated with the process of neural entrainment; the repetitive neural firing with temporally predictable events, in which brain activity synchronises with the rhythm (Doelling & Poeppel, 2015). This rhythmic neuronal firing can continue without any further input from the original rhythmic source, allowing individuals to predict or anticipate when the next beat will occur, thus, proving a steady time cue so that the brain is able to "plan ahead" (Figure 1).

It is important to note, however, that some individuals with PD have particularly poor beat perception due to damage in the basal ganglia (Grahn & Brett, 2009), which makes synchronising their movement to a beat alone difficult (Dalla Bella et al., 2017). Certain musical properties, such as 'groove', may emphasise the beat and make synchronising movements with a rhythm easier, compared to a lone beat (Dalla Bella, 2015; Hove & Keller, 2015; Janata, Tomic & Haberman 2012; Leow, Parrott, & Grahn, 2014; Thaut, McIntosh, Rice, 1997). Groove is defined as the musical feature that urges us to move (Janata et al., 2012). Indeed music which is high in groove, has been demonstrated to induce more fluent gait in healthy individuals with low beat perception abilities (Leow et al., 2014). Therefore groove, which does not rely solely on beat perception, may provide a better cue for synchronising movement in individuals with PD.

These examples, coupled with the TMCM, illustrate the capacity of music to induce synchronisation of motor responses through auditory motor coupling, shared networks and neuroplastic change, leading to improvements in fluency of speech and movement in people with PD, stroke and ASD (Figure 1).

2.5. Music is *personal*

The decline in physical and cognitive abilities that occur alongside neurological conditions, such as AD or stroke can bring about a diminished sense of self. This is a fundamental problem as it ultimately results in poor quality of life. For example, the decline in memory function in AD, particularly the ability to recall autobiographical memories, contributes to a loss of identity and subsequently compromises well-being (Jetten, Haslam, Pugliese, Tonks & Haslam, 2010). For individuals who have had a stroke, the loss of motor functioning and impaired speech fluency may impact on their sense of physical and social identity (Dickson, Barbour, Brady, Clark & Paton, 2008; Murray & Harrison, 2004). In turn, depression and anxiety frequently arise out of this loss of social identity (Ayerbe, Ayis, Crichton, Wolfe, & Rudd, 2014; Campbell Burton, Murray, Holmes, Astin, Greenwood & Knapp, 2013; Hackett, Yapa, Parag, & Anderson, 2005).

Music may assist in the reconstruction and maintenance of identity, as our favourite music often signifies defining moments in our life; the first time we met a romantic partner or participated in activities we once loved, such as dancing or parties. With technological advances, our ability to access and listen to music has increased significantly. Unlimited access to these favourite songs means that music can be used for everyday therapeutic benefits, such as modulating our emotions (Randall, Rickard & Vella-Brodrick, 2014) and activity levels (Hutchinson et al., 2018; Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006). We can also tailor our music experience through personalised play lists and create a personal soundtrack to our lives (Davidson & Garrido, 2014). In this way, listening to personally preferred music can assist people with dementia in recalling autobiographical memories and becoming familiar with new environments, while also reducing agitation and anxiety. It can also be used as a way to improve mood and relax in the recovery period following a stroke. Ultimately, music can boost quality of life in these neurological populations.

There is increasing interest in using personalised playlists as a therapeutic tool for people with dementia (Garrido et al., 2017). Anecdotal evidence from caregivers and family members reports marked changes in mood, physical ability and verbal responses following their person with dementia listening to a favourite song. This attests to the use of this idea as a therapeutic practice, with the relevant literature supporting it (e.g., Gerdner 2000; Sung, Chang and Lee, 2010). As mentioned previously, the decline in cognitive ability hinders the recall of autobiographical memories for people with AD. However, personally preferred music can be particularly helpful for recalling autobiographical memories in AD when compared to researcher chosen music or silence. Furthermore, these memories tend to be expressed more fluently, with greater grammatical complexity and containing fewer missing words (El Haj, Clement, Fasotti & Allain, 2013). Music's capacity to trigger autobiographical memories can address the loss of identity in people with AD. According to Baird and Thompson (2018), music is valuable for five dimensions of the 'self': the ecological (immediate sensations of one's physical conditions), interpersonal (how we present ourselves to others), extended (how our present identity relates to who we were, and who we might be in the future), private (a sense of self that we keep to ourselves) and conceptual (a concept of ourselves, for example as "an artist" or "a scientist"). For example, the triggering of autobiographical memories may contribute to the maintenance of the 'extended self' by providing access to the self as it was in the past, embodied in the autobiographical memory. These music -evoked memories also provide a route to the 'private self', given their association with extremely personal thoughts and feelings.

Music has also been shown to soothe people with dementia and reduce their levels of agitation during and up to one hour after music listening has ceased (Gerdner & Swanson, 1993; Gerdner, 2000). Levels of agitation were less after listening to personally preferred music compared to relaxing classical music (Gerdner 2000), demonstrating the importance of personally relevant music. In a review of the literature, Sung and Chang (2005) concluded that despite some methodological limitations, such as small sample sizes, personalised music listening could be an effective therapeutic tool to reduce problem behaviours in people with dementia and a potential alternative to medication. In addition to reducing agitation, Sung, Chang and Lee (2010) found that a preferred music listening intervention could also reduce anxiety levels in people with dementia compared to standard care with no music. The familiarity we have with certain music can also be used to help people with dementia to become more readily oriented with a new environment or maximise their sense of familiarity in a current one (Son, Therrien & Whall, 2002). Intact implicit memory in AD may explain why familiar stimuli, such as music, can be a successful therapeutic tool (Figure 1) (Randolph, Tierney & Chase, 1995).

To gain further understanding of how personal music playlists can be used in the rehabilitative process after stroke, Forsblom et al., (2009) conducted interviews with stroke patients and nurses. This study followed on from that of Särkämö et al., (2008) in which stroke patients listened to their favourite music during a three-month period of stroke recovery. Typically in the first few days to first few months of the stroke recovery period, patients often report feelings of shock, confusion, helplessness, followed by anxiety, depression, irritability and tiredness (Cullberg, 2007). However, during these periods of time in the music listening intervention, the majority of participants reported that the music helped these symptoms by inducing a more positive mood (95%), memories and reflective thoughts (85%) and, a state of calm, relaxation and improvement in sleep (80%) and memories and reflective thoughts (85%). Overall, 75% of the patients felt music- listening had contributed positively to their recovery. All of these changes were also reported by the majority of participants (70%) as contributing to their recovery from stroke. Further, three months after their stroke, participants who had been listening to their personal music reported significantly lower depression scores. The personal music listening also promoted the relationship between nurse and patient. The nurses reported having greater insight into the thoughts and feelings of the patient. These self- reported benefits are in line with the aforementioned negative psychological symptoms during the recovery period after stroke. Therefore, listening to personal music can be successfully implemented and is highly valued for the recovery needs of patients with stroke.

It is evident that the personal capacity of music can improve a sense of well-being through its positive impact on mood and overall recovery in stroke rehabilitation, and also on behaviour (a reduction in agitation and social isolation), mood and identity in people with dementia. This research provides support for the link between the personal capacity of music and the psychosocial, cognitive and behavioural outcomes in the TMCM (Figure 1).

2.6. Music is *social*

Another contributing factor to the decline in quality of life of individuals with neurological impairment is the reduced ability to participate in social activities. The cognitive deficits faced by individuals who have had a stroke make it significantly harder to maintain their meaningful activities and group memberships, which impacts negatively on their sense of well-being (Mukherjee, Levin & Heller, 2006). A decrease in quality of life over several years in people with PD has been attributed to an increase in distress pertaining to issues of social isolation (Karlsen, Tandberg, Arsland & Larsen, 2000). Furthermore, social activities have been shown to be beneficial, and potentially protective, against cognitive decline in older individuals (Wang, Karp, Winblad & Fratiglioni, 2002). It is possible that when we engage socially, we exercise a broad range of cognitive processes (attention, working memory, processing speed and inhibition), which form the basis of more specific processes needed for social interactions (e.g., empathy and mentalising, see Ybarra et al., 2008). From another angle, the challenges of social interaction associated with ASD often result in an increased risk of loneliness (Bauminger & Kasari, 2000) and ostracising from an individual's typically developing peers (Chamberlain, Kasari & Rotheram-Fuller, 2007). These neurological problems demonstrate a need for a group-based activity, which encourages social reciprocity without placing unrealistic or inappropriate demands on cognitive or physical abilities.

Music making and listening is a meaningful activity that invites social interaction without requiring excessive cognitive or physical effort. Music has long been used to bring people together and define group membership, especially in adolescence. Importantly, we know that participating in group music activities results in many rewarding effects. Studies of healthy individuals have shown that the effects of social cohesion specifically feelings of closeness, are more rapid when we sing in a group compared to when we engage in other group activities, such as craft or writing (Pearce, Launay & Dunbar, 2015; Weinstein, Launay, Pearce, Dunbar, Stewart, 2016). For example, when making music or moving together in a social context there is a release of neurohormones such as oxytocin, which is involved in elements of social bonding, such as empathy (Domes, Heinrichs, Michel, Berger & Herpertz, 2007; Tarr, Launay & Dunbar, 2014) and trust (Kosfeld, Heinrichs, Zak, Fischbacher & Fehr, 2005; Tarr et al., 2014) (Figure 1). Numerous therapeutic benefits for individuals with neurological disorders have been attributed to these social capabilities of music. In particular, group singing can lessen agitation and isolation in people with dementia (Harris & Caporella, 2014; Lesta & Petocz, 2006), improve mood in people with aphasia and PD (Abell, Baird & Chalmers, 2017; Baird et al. 2018; Tamplin, Baker, Jones, Way & Lee, 2013) and encourage social interactions in children with ASD (Kim, Wigram & Gold, 2008; LaGasse, 2014). In all these cases, these benefits ultimately improve quality of life.

Group singing has been used to counteract 'sundowning' (delirium and agitation during the later stages of the day) in people with dementia, successfully decreasing non-social behaviour and improving mood in a residential aged care facility (Lesta & Petocz, 2006). Including carers of people with dementia in a singing group has seen improvements in mood, social relationships, and the acceptance of the dementia diagnosis in the person with dementia (Osman, Tischler & Scheider; 2016). The maintenance of quality of life has also been shown to improve after group singing for both the carer and person with dementia, despite increase in dementia symptoms (Camic, Williams & Meeten, 2013). In addition, group singing involving both young college students and people with AD has been shown to decrease the negative attitudes and stigma amongst the younger participants in contact with those with the disease, while also decreasing social isolation of people with AD (Harris & Caporella, 2014).

Positive psychological and social effects after participating in a community choir have been reported for people with aphasia following stroke (Tamplin et al., 2013). Measurements taken prior to participating in the choir revealed that participants had higher levels of negative mood and a poorer subjective sense of belonging compared to those of average Australians. After participating for 20 weeks in the choir, there was a trend towards a decrease in psychological distress. Participants also reported an increase in confidence, mood and motivation, peer support, and changes to communication (Figure 1). Singing groups show similar positive effects on mood in people with PD (Abell et al., 2017; Baird et al. 2018), although one study found no improvement (Elefant, Baker, Lotan, Lagesen & Skeie, 2012). A thematic analysis exploring the self-reported experiences of participating in a singing group for people with stroke and PD revealed some of the benefits to be an improvement in mood, language, breathing and voice, and further, assisted in reducing social isolation (Fogg-Rogers et al., 2016).

Music can be used as an indirect form of communication, and therefore can facilitate social engagement in children with ASD who are minimally verbal or non-verbal (Kern & Aldridge, 2006; Kim et al, 2008; LaGasse, 2014; Wigram & Gold, 2006). Music, and more specifically song, is used by caregivers to communicate with infants before language is possible (e.g., Trehub & Trainor, 1998). As newborns, we are highly tuned in to the fluctuations in pitch and rhythm of speech from a mother or primary care giver. We are, therefore, already adapted to using the musicality of speech in a social context to decode meaning and communicate before we can speak. Improvising or “free playing” with music can be employed between a Music Therapist and child with ASD as a form of communication. Making music activates the MNS and subsequently encourages eye contact and imitation, which are evident in conversation and non-verbal social interactions (Figure 1) (Raglio, Traficante & Oasi, 2011). In this way, music can be used to mimic social situations, and encourage children with ASD to improve their interaction skills. LaGasse (2014) compared social behaviour of children with ASD after participating in a Music Therapy group to those in a no-music social skills group. The children who participated in the Music Therapy demonstrated greater improvements in joint attention and eye gaze towards others. Music Therapy has also been shown to be more effective in inviting other joint attention behaviours such as pointing or showing as well as eye gaze and turn-taking (Kim et al., 2008). Therefore, music making for children with ASD permits communication through a musical framework, but without the constraints of language. This encourages social interaction and helps to build bonds.

As demonstrated in the TMCM and the examples above, the social nature of music enhances the therapeutic experience, leading to improvements in behavioural functioning in children with ASD (through the mirror-neuron network and emotion processing), and in mood and social isolation in people with dementia, PD and stroke (Figure 1).

2.7. Music is *persuasive*

Music's persuasive nature makes it a highly effective device in reinforcing, changing or inspiring belief (for review see Brown & Volgsten, 2006). The positive belief in a treatment may make participating in recovery more likely, as posited by the *Health Belief Model* (Rosenstock, 1974). In other words, merely believing that a treatment will lead to positive outcomes can amplify therapeutic benefits. For example, the highest contributor of the intention to exercise as a way of reducing the likelihood of having a stroke in at risk individuals was the perceived benefit of partaking in exercise (Sullivan, White, Young, & Scott, 2008).

Music interacts with belief systems by evoking powerful emotions that highlight the significance of accompanying media, such as lyrical content, or visual signals (e.g., Thompson & Russo, 2004). Emotion is an important facilitator of beliefs as it enables one to form connections and attach significance to certain contexts and modifying behaviours (Figure 1). This has been exploited in a wide variety of contexts, from ancient healing and religious rituals, to media advertisements and political movements (Dissanayake, 2006; Street, Hague & Savigny, 2008). For example, early studies looking at the effect of background music on shoppers in supermarkets found that the tempo of music played in the store had a significant influence on customer purchases. Songs with a slower tempo made the shoppers walk at a slower pace and thus spend more. Whereas songs with a faster tempo meant that shoppers were in and out of the store faster (Milliman, 1982). Film music is another way in which background music can persuade an individual and reinforce belief. A series of experiments examined the effect that music had on narrative persuasion. Participants viewed short film clips that were either presented with or without the music intended for the clip. Music that was originally intended for the short film was rated by the participants as generating a greater sense of 'transportation into the film' and coherence with the beliefs expressed in the film (Costabile & Terman, 2013). These findings suggest that the persuasive nature of music is deceptively powerful because ideas are not explicitly forced upon us. Rather, this process occurs implicitly, allowing us to maintain a sense of agency over our beliefs, making them more robust.

Music is universally connected with therapeutic practice (Gouk, 2017). This can range from the individual experience of listening to a favourite song for stress relief or making music in a group setting such as a spiritual ritual. The success and longevity of such customs is due to the fact that music is universally felt to uplift us, encourage us and revitalise us. For example, music is used in Shamanism for trance induction, allowing one to reach a supreme state of consciousness that is often used in the healing process. Rhythmical music is often used specifically in this ritual to create a bond between the healer and patient, which is said to maximise the belief system and positively affect the therapeutic process (Moreno, 1995). In some ways, parallels can be drawn between this use of music and that between a Music Therapist and client in the practice of Music Therapy. Music in shamanic rituals is also used as a way of distracting the individual and allowing them to 'let go' (Moreno, 1988). In these ways the music is used as a way to reinforce the patients' belief in their capacity to actively influence their healing (Moreno, 1995).

From another angle, in a therapeutic setting, enjoyment tends to increase motivation for participating in treatment, and optimism for its effectiveness. Individuals typically experience music to be an enjoyable personal or social activity. As such, dance interventions tend to be viewed by the elderly as more enjoyable than exercise alone (Federici, Bellagamba & Rocchi, 2005). These views have been found to promote adherence to treatment programs and enhance motivation, not only in participating in programs but also in pursuing healthy lifestyle behaviours.

Thus, music is persuasive in the sense that it highlights and supports accompanying ideas, interacting with our belief systems, and in turn enhancing therapeutic success. Belief is crucial when initiating any rehabilitative process as it can impact positively on the patients' continual willingness to engage in treatment.

3. Concluding remarks

Research throughout the last two decades has improved our understanding of the neural mechanisms behind music's therapeutic value and the cognitive, emotional, motor, sensory and social domains upon which music acts. In this review, we have proposed the *Therapeutic Music Capacities Model,* which provides a preliminary structure for conceptualising what is at the core of music's value as a therapy, specifically for neurological disorders. We have discussed pertinent examples from research on neurological disorders, specifically dementia, PD, stroke and ASD, in order to demonstrate how the seven capacities of music work to achieve behavioural, cognitive, psychosocial and motoric outcomes. Firstly, music is *engaging* by simultaneously activating multiple networks within the brain, creating an enriched multisensory experience. It also sustains attention and motivates patients to participate in treatment. Its *emotional* nature reinforces a sense of identity through the retrieval of memories, providing an alternate way of understanding communication and enhancing awareness. Music elicits *physical* movements, assisting with mobility and maintaining cognitive function and affords *synchronisation* of these movements, helping improve motor and verbal fluency. Music is *personal*, which enables recovery to be tailored to the individual, consequently maximising its behavioural and psychological benefits. Music can also be *social* which helps to reduce feelings of isolation. Finally, music is *persuasive* in a way that enhances the meaning of therapeutic messages as well as providing hope for the treatment's beneficial effects.

Each of these seven individual, yet inter-related, musical attributes has the potential to address various symptoms of these neurological disorders, but it is rarely the case that they occur independently in music listening or music making. Indeed, one of the reasons music is so powerful as a treatment is due to the combination of these attributes, resulting in a cumulative benefit. In a research setting, it is challenging to examine each individual attribute separately as they are difficult to disentangle from one another. Attempts to isolate each attribute may result in over-simplified stimuli that underestimate the richness of real-world musical experiences. Despite this, these seven qualities can be clearly associated with mechanisms of action. These mechanisms may interact in different ways, but as yet their level of interaction is not yet fully understood. This understanding requires continued investigation and may involve many concerted research efforts. What remains clear, however, is that music is a rich experience that contains powerful therapeutic ingredients.

Our model provides a framework for understanding these ingredients and developing treatment protocols and, as research evolves, music-based treatments are likely to become increasingly efficacious. The model also provides a framework for the development of personalised music-based treatments. For example, neurological disorders in which a patient is displaying agitation and experiencing feelings of isolation may require the therapist to enhance the music capacities of *social, synchronous* and *personal* in developing a music treatment specifically for the individual patient. This type of framework is critical for generating a comprehensive and structured understanding of not only how, but also *why* music, as a unique stimulus, works for the rehabilitation of neurological disorders. Through this understanding, we may be able to develop more targeted music-based treatments that address specific dysfunctional processes, while simultaneously meeting the psychological, behavioural and physical needs of individual patients.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

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CHAPTER 1

Chapter 2:

Music and its therapeutic role in dementia care

As established in Chapter 1, the Therapeutic Music Capacities Model explains why music is a valuable therapeutic tool for a range of neurological disorders. Chapter 2 focusses on the benefits of music for people with dementia and outlines theoretical and empirical grounds for the development of a new music-based treatment program: The Music, Mind and Movement program. Manuscript 2 was prepared as a book chapter in *'Music and Dementia: From Cognition to Therapy'* and co-authored by Bill Thompson and myself. As the primary contributor, I conducted the literature review and prepared the first full draft. Bill Thompson provided valuable input and made substantial comments, suggestions, and revisions on the manuscript. As such, references to chapters throughout this manuscript correspond to chapters in the book.

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CHAPTER 2

Chapter 3:

The Music, Mind and Movement Program

As presented in Chapter 2, the TMCM can account for the therapeutic value of music in dementia care. Chapter 3 presents an empirical investigation that supports this framework. According to the TMCM, seven capacities of music are especially valuable in providing cognitive, psychosocial, behavioural and motor benefits. In order to evaluate this framework, we first developed the *Music, Mind and Movement* (MMM) program, which translates a theoretical model into concrete activities that should lead to beneficial outcomes for this population. The MMM program differs from existing music-based programs in two ways. Firstly, the activities outlined in the program are directly linked to underlying mechanisms identified in the TMCM. Secondly, the activities are designed to recruit multiple capacities of music, a feature that contrasts with other music programs that focus on only one or two capacities. Drawing on measures of cognition, mood, identity and motor benefits, I investigated the effect of the MMM program for people with dementia living in a residential aged care facility.

As part of this research, we developed the MMM Program Manual (Appendix II) that was given to carers and nursing staff at aged care facilities. The manual describes the MMM program and the activities within each session in sufficient detail for staff at the residential aged care facility to run the program.

CHAPTER 3

Manuscript 3 describes this study and was co-authored by myself, Amee Baird and Bill Thompson. I contributed approximately 80% of the total work, which included designing the experiment and program, data collection, data analysis, and preparation of the initial manuscript draft. Amee Baird and Bill Thompson provided valuable input on the experimental design, design of the program, interpretation of the data, and manuscript preparation.

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A 'Music, Mind and Movement' Pilot Program for People with Dementia: Evidence of Improving Cognition.

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CHAPTER 3

Abstract

Music is being increasingly used as a therapeutic tool for people with dementia. Research is revealing some of the specific qualities of music that are responsible for its beneficial effects. Based on the identification of seven distinct therapeutic capacities of music, this study devised the *Music, Mind and Movement* (MMM) program and evaluated whether it had therapeutic benefit for people with dementia in the areas of cognition, mood, identity and motor fluency. The MMM program involved seven 45-minute weekly group sessions, and individual 15-minute “booster” sessions. Twenty people with mild to moderate dementia participated. Group 1 (n=10) completed the MMM program first and Group 2 (n=10) acted as a wait list control for the first 7 weeks, receiving standard care and completing the MMM program after the first group. Assessments of cognition (Addenbrooke’s Cognitive examination, ACE), mood (Geriatric Depression Scale short form), identity (‘I am/I was’ task), and fine motor skills (9-Hole peg task) were conducted at baseline (T1), Time 2 (T2, post treatment) and Time 3 (T3, one month post MMM program). Selected assessments were obtained to measure contribution of the specific capacities of music. Twelve participants from the MMM program and 10 participants from the control condition were analyzed. There was a decrease in cognition (total ACE score) in the control group who received standard care from 59.40 to 55.20 ($p = .047$). In the MMM condition, there was a marginally significant increase in mean total ACE score from 57.00 to 60.58 (p=.059). Significant differences were present in the ACE sub-scores of attention ($p = .005$) and verbal fluency ($p = .049$). Our preliminary findings suggest that the MMM program may improve cognition, particularly verbal fluency and attention, in people with dementia.

Key words: Music, movement, dementia, cognition, fluency, attention, therapeutic.

1. Introduction

Dementia is an umbrella term used to describe a group of neurodegenerative disorders that cause a decline in cognitive function, impacting on everyday skills. Currently, dementia affects approximately 50 million people worldwide (Alzheimer's Disease International). The most common form of dementia is that of the Alzheimer's type, accounting for approximately 70% of cases. Alzheimer's dementia (AD) primarily involves problems with memory. There is no cure for dementia, although certain pharmacological treatments can improve some symptoms (e.g. Howard et al., 2012). However, many of these pharmacological treatments have side effects and are ineffective for some individuals. Therefore, there is a demand for non-pharmacological treatments, especially if such alternative therapies confer behavioral and psychological benefits that are equal to those observed for pharmacological therapies, without any of the adverse events (Dyer, Harrison, Laver, Whitehead & Crotty, 2018).

Music has been used as a therapeutic intervention for numerous neurological disorders, particularly in dementia care (for review see Altenmuller & Schlaug, 2013; Thompson & Schlaug, 2015). It has been proposed that the therapeutic value of music may be attributed to seven distinct capacities of music. Namely, that music is persuasive, engaging, emotional, personal, physical, and social, and it affords synchronization (Thompson & Schlaug, 2015). Together, they comprise a robust blend of affordances that can be used in a therapeutic setting to address many of the symptoms of dementia, such as memory decline, decreased language fluency, and an altered sense of self (Brancatisano & Thompson, in press). These capacities form the basis of the Therapeutic Music Capacities Model (TMCM, Figure 1), which outlines the capacities and the therapeutic outcomes that arise as a result of their therapeutic potential. We evaluated the efficacy of a newly developed music-based program, the Music Mind and Movement (MMM) program, which is based on this model.

There are three fundamental advantages of using music for therapy with people with dementia. Firstly, music is easy to access and deliver as therapy. Particularly with recent advances in technology, music is more ubiquitous than ever before. We have access to thousands of songs, spanning culture and time, in a range of settings, from individual music listening with iPods to group settings. This makes music suitable to the dementia population since individuals are able to partake in the experience (whether through listening, moving or music making) irrespective of their level of functioning. Furthermore, the negative side effects of such interventions are rare. Negative experiences of music can arise if the music is intrusive or otherwise unappealing (Chang, Huang, Lin & Lin, 2010; Nair et al., 2011), or if the music reinforces depressive tendencies (Garrido et al., 2017; Garrido, Stevens, Chang, Dunne & Perz, 2018). Such negative effects tend to be transient and easily managed by removing the individual from the musical source.

Secondly, musical functions, including some forms of musical memory, are often spared in the face of AD, even during the most severe stage. Some of these preserved musical abilities include the detection of wrong notes in familiar songs (Cuddy & Duffin, 2005), learning new songs in both musicians with dementia (Cowles et al., 2003) and non-musicians with dementia (Baird, Umbach & Thompson, 2017; Prickett & Moore, 1991; Samson, Dellacherie, & Platel, 2009), the ability to detect emotional meaning in music (Drapeau, Gosselin, Gagnon, Peretz & Lorrain, 2009) and show emotional responses to music such as joy (Baird & Thompson, 2018; Norberg, Melin & Asplund, 2003). These observations of spared music abilities in these individuals opened the door to the possibility of using it as a means of therapy in dementia care.

Lastly, music can prime or scaffold other (non-musical) functions. For example, music can stimulate autobiographical memory (e.g. Irish et al., 2006; Baird, Brancatisano, Gelding & Thompson, 2018). It also engages the individual in new learning, exercise and cognitive training, and thus can reinforce the processes of 'neural scaffolding'. This is a process, originally defined by Park and Reuter-Lorenz (2009) in their 'Scaffolding Theory of Aging and Cognition' (STAC) model, which explains how life-course factors can enhance or deplete neural resources, influencing the developmental course of cognition and brain function. The STAC model proposes that as individuals age, certain enriching factors may enable 'compensatory scaffolding' to occur, which may protect against cognitive decline. In the face of dementia, neuropathology may undermine the brain's ability to provide effective compensation. Music and its broad network of capacities can engage brain regions that are typically involved in neural scaffolding, such as frontal areas that are typically relatively preserved in people with the most common type of dementia, AD.

In the last decade music-based activities have been implemented as a way of alleviating negative symptomology associated with the dementias (primarily for AD), such as agitation (Raglio, 2010), anxiety (Sung, Chang & Lee, 2010; Sung, Lee, Li & Watson, 2012) and depression (Ray & Mittleman, 2017). Further, cognitive function has been shown to improve during or immediately after music-based treatments (Van de Winckel, Feys, De Weerdt & Dom, 2004; Chu et al., 2014; Särkämö et al., 2014). There have been two Cochrane reviews that have examined the effectiveness of music interventions for behavioral, emotional and cognitive outcomes in people with dementia (Vink, Bruinsma & Scholten, 2003; Van der Steen et al., 2017). Vink et al. (2003) included ten randomised control trials (RCTs) and the second, more recently, by Van der Steen et al. (2017) included 17 RCTs. Vink et al. (2003) stated that no conclusions could be drawn as the quality of methods was poor overall. However, later, the 2017 study was able to conclude that the evidence was 'moderately strong' to support the use of music to improve symptoms of depression, but not agitation or aggression. Evidence that music can improve mood, cognition, anxiety and social interaction was low, with issues such as risk of bias and small sample sizes. Thus, whilst there is support for music as a treatment for certain symptoms of dementia, ambiguity exists surrounding its effectiveness for various other symptoms of dementia.

Part of the reason for this ambiguity may be the multitude of different ways music is used therapeutically. Music interventions range from traditional music therapy, an evidence-based practice involving a trained music therapist, to music-based programs led by a musician or facilitator with no music training. These music-based programs can involve listening to music (receptive) or music making (active), such as singing or using an instrument. The music used in these interventions can be researcher or participant chosen depending on the outcome desired, such as using personal music to promote reminiscence. In addition, these activities can be done either individually or in a group. Each of these modes of therapies has a variety of beneficial effects. Active music therapy in a group setting has been shown to improve general cognition, measured using the MMSE (Bruer, Spitznagel & Cloninger, 2007; Chu et al., 2014), and specific cognition functions, such as verbal fluency (Brotons & Koger, 2000; Lyu et al., 2018). Group music therapy has also demonstrated benefits by reducing associated symptoms of dementia such as depression (Chu et al., 2014) and agitation (Lin et al., 2011; Raglio et al., 2010; Tsoi et al., 2018; Vink et al., 2013). Group music-based treatments as distinct from music therapy, such as music listening and making or moving to music, have also been shown to improve general cognition (Cheung, Lai, Wong & Leung, 2018; Särkämö et al., 2014; Tang et al., 2018; Van de Winckel et al., 2004), in addition to specific cognitive functions, such as attention and executive function (Särkämö et al., 2014) and, verbal fluency and memory (Cheung et al., 2018). As with music therapy, group music-based treatments have also reduced symptoms of apathy (Tang et al., 2018), agitation (Choi, Lee, Cheong & Lee, 2009; Ho et al., 2018) and depression (Ashida, 2000). Additionally, individualised music treatments, such as the use of personalised playlists, have been used to encourage the discontinued use of antipsychotic medication (Thomas et al., 2017). Overall, it is clear that music has a multitude of ways in which it interacts as a therapeutic context for people with dementia.

Many interventions for people with dementia contain some of the same therapeutic qualities as music. For example, cooking and art therapy are engaging, social and can invite personal reflection. In some instances, these therapies have offered similar benefits to music-based therapies. In one study, a cooking intervention and music intervention (involving singing and instrument playing) resulted in similar short-term reduction of behavioral disorders in people with AD (Narme et al., 2014). However, it was only the music intervention that continued to have this effect long term. Other forms of therapy do not include some of music's additional qualities that may lead to its extra therapeutic benefits. For example, music allows us to synchronize our actions, which promotes social bonding. Music can also induce spontaneous movement, which may confer cognitive benefits (Verghese et al., 2003). In addition, music has the innate ability to move us emotionally in the same manner as stimuli that affect the hedonic centres in the brain, such as food and drugs (Blood & Zatorre, 2001). It is this combination of a number of capacities that makes music an 'all in one' therapeutic approach. Whilst this is one of music's strengths, it also makes it a complex treatment tool to understand experimentally.

CHAPTER 3

Experimental and review studies are contributing significant knowledge to devising successful music programs to improve dementia related symptoms. However, the majority of research has not identified the various capacities by which music can confer beneficial therapeutic effects. Moreover, there is no overarching theoretical model of the therapeutic value of music. To address this issue, Thompson and Schlaug (2015) proposed seven capacities of music that explain why it may be an ideal treatment tool for neurological disorders such as dementia. As described in detail below, these seven attributes are that music is engaging, persuasive, emotional, personal, physical and social and permits synchronization. Understanding these capacities should allow for more effective music interventions in the management of people with dementia.

1.1. The seven capacities of music

Music is engaging. Music activates multiple systems in the brain simultaneously, from frontal, parietal, temporal and cerebellar to deeper limbic structures (e.g., Blood & Zatorre, 2001; Zatorre & Salimpoor, 2013). By engaging multiple processes, it places the brain in an 'enriched' and challenging setting, triggering neuroplasticity. In addition, by casting a 'wide net' of engagement, this offers multiple opportunities for addressing deficits. In particular, music can facilitate the encoding of verbal material by enhancing neural coherence during new learning (Peterson & Thaut, 2007). Whilst healthy individuals may not need to rely on music-enhanced encoding because they have intact cortical structures for memory, the mnemonic benefits provided by music may be necessary for individuals with AD (Kilgour, Jakobsen & Cuddy, 2000). In effect, music provides a comprehensive, neurological scaffold for memory. Music also captures our attention such that we are likely to pursue the therapy in an undistracted manner, thereby reaping maximum benefits.

Music is emotional. One of the most significant purposes of music is to convey emotional meaning. From a structural point of view, areas involved in emotion processing, namely the medial frontal and limbic areas are relatively spared from degeneration in AD (Jacobsen et al., 2015). The way in which music can heighten emotions can be utilized to reduce apathy (loss of interest and a lack of or blunted emotional responses) in people with moderate to severe AD (Massaia et al., 2018; Tang et al., 2018). Receptive music- based treatments have been shown to significantly improve apathy (Massaia et al., 2018; Tang et al., 2018) and increase smiling behaviors compared to a control intervention of standard care (Raglio et al., 2008). Music also plays an important role in re-gaining access to emotions and memories, particularly in people with AD (e.g., Baird et al., 2018; El Haj, Fasotti & Allain, 2012). Interestingly, episodic memories evoked by music in people with AD tend to contain more emotional content and are more positively valanced, than episodic memories evoked in silence (Cuddy, Sikka, Silveira, Bai & Vanstone, 2017; El Haj et al., 2012), implying that the effects of music can benefit people with AD not only by eliciting memories, but also by inducing a positive state of mind.

Music is inherently a very physical stimulus. It is hard to separate the experiences of music and movement; when we hear certain types of music we get a strong urge to move our body to the music. Engaging in physical exercise has been known to delay the onset of dementia (for review see Carvalho, Rea, Parimon & Cusack, 2014; Larson et al., 2006; Laurin, Verreault, Lindsay, MacPherson, Rockwood, 2001). Furthermore, in a longitudinal review over 5 years, engagement in leisure activities, such as dancing, reduced the risk of dementia (Verghese, et al., 2003). Interventions that have paired music and exercise in people with dementia have seen a decrease in depression, as well as improvements in specific cognitive functions such as verbal fluency and memory (e.g., Cheung et al., 2018). Exercise and its associated benefits for memory may be accompanied by an increase in the production of brain derived neurotrophic factor which mediates neurogenesis (Erickson et al., 2011). Pairing music and movement therefore encourages exercise and subsequently benefits cognition, mood and behavior.

Music affords synchronization. We have an instinctive ability to synchronize our body's movements, and speech, to music. Simply moving in time with one another to music has many positive therapeutic benefits. For example, in synchronous drumming there is a release of endorphins and neurochemicals that are responsible for feelings of social bonding, empathy and trust (Tarr, Launay & Dunbar, 2014). The tendency to move in time to music may assist in learning new movement sequences in people with AD (Moussard, Bigand, Belleville, & Peretz, 2014). Music treatments that have emphasised synchronizing the playing of musical instruments have resulted in improvement in cognitive functions such as verbal fluency, supported by neuroimaging results which demonstrate an increase in the level of cerebral blood flow to the prefrontal cortex (Shimizu, Umemura, Matsunaga & Hirai, 2017).

Music is personal through its ability to reinforce our sense of self as it is commonly linked with our identity. Music that is heard repeatedly during significant or pivotal times in our personal development eventually seems to signify that time of life. Personalised playlists are becoming increasingly used in care facilities for people with dementia, especially in those with moderate to severe cognitive decline. Levels of agitation have been reported to decrease after listening to personally preferred music compared to relaxing classical music (Gerdner 2000). Preferred music listening interventions can also reduce anxiety levels in people with dementia compared to standard care with no music (Sung & Chang, 2005; Sung, Chang & Lee, 2010). Familiar music can also be used to help people with dementia become more oriented within a new environment or maximise their sense of familiarity in a current one (Son, Therrien & Whall, 2002).

Music is social. Isolation is one of the most significant challenges associated with dementia, due to the decline in behavioral and cognitive functions. Music acts as a catalyst for bringing people together and also enhances group experiences. The social nature of music may be beneficial in boosting the healing process via cohesion, collective enjoyment and a sense of support for one another. Improvements have been demonstrated in cognitive functions (e.g., attention), behavior, mood and wellbeing after participating in group singing and music activities (Narme et al., 2014; Sakamoto, Ando & Tsutou, 2013; Särkämö et al., 2014). Importantly, many people with dementia also indicate that group singing helped them to accept and cope with their disease (Osman, Tischler & Schneider, 2016).

Music is persuasive, and belief in a treatment is crucial for participation, motivation, and recovery. The positive belief in a treatment may make participating in therapy more likely (Rosenstock, 1974). In other words, merely believing that a treatment will lead to positive outcomes can amplify the therapeutic benefits. Music has the capacity to persuade or influence us and has been used historically as a tool to reinforce, change or inspire beliefs. For example, messages in advertisements or political movements are highlighted and enriched by music. It is persuasive also in the sense that the sheer enjoyment it stimulates leads to an optimistic outlook, such as in a therapeutic setting.

We have taken these seven capacities of music and developed the TMCM (Figure 1) (Brancatisano & Thompson, in press). Briefly, the model begins with some of the contexts in which music can be experienced in a therapeutic way, previously identified by MacDonald, Kreutz and Mitchell (2012). These contexts then break into the seven capacities that form the core of the model. These seven capacities were proposed by Thompson and Schlaug (2016) and are a simplification of work by MacDonald et al., (2012), who initially identified a system of ten qualities of music which drive the relationship between music, health and wellbeing. A number of biological and psychological processes are then listed that may underlie the link between the seven individual capacities of music and their beneficial outcomes. Finally, arising from the seven capacities through the underlying mechanisms, are multiple potential benefits, including cognitive, psychosocial, motor and behavioral. As it stands, most music-based treatments or music therapy practices incorporate one or several of these attributes, but not all. These attributes have not yet been combined to form an intervention in a systematic way, which may in turn maximise the effect of a music-based intervention.

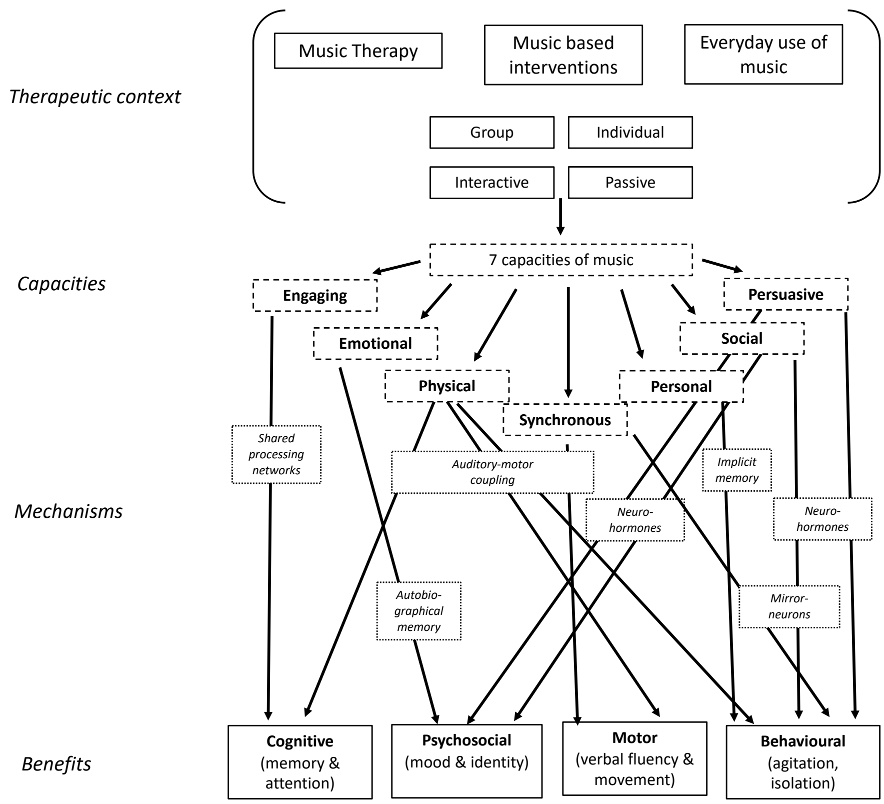

Figure 1. The Therapeutic Music Capacities Model (TMCM).

We devised the Music, Mind and Movement (MMM) program based on the TMCM. The MMM program was then evaluated in people with dementia to a) determine the potential benefits that including all seven capacities would have on the participants' cognition, mood, identity and motor function, b) determine the impact that certain individual or a combination of capacities would have on the participants' cognition, mood, identity and motor function and c) explore the relationship between the number of sessions attended, time in residency, age, years of education and, cognition and mood. In addition, we sought to ascertain subjective responses toward the MMM program

2. Methods

2.1. Ethical approval

Ethical approval was granted by the Macquarie University Human Sciences Ethics committee. Approval was also obtained from the residential aged care facility. Verbal consent to approach the participants was first sought from their significant other (family member or partner). Written and informed consent was obtained from all participants, as follows. All participants underwent an initial visit to explain the study and gauge their interest. If participants were interested, a second visit was organised for verbal and written consent from the participant and their significant other. Continuing consent was monitored each week with each participant being re-told the nature of the program and asked if they were happy to participate. If the participants declined they would be asked again to take part the following week. If they declined due to disinterest two weeks in a row, they were excluded from the study.

2.2. Participants

We recruited participants from a local residential aged care facility who had either a clinical diagnosis of any type of dementia (mild to moderate) or indication of cognitive impairment (e.g., mild cognitive impairment, amnesia) as specified in their medical records. Evidence of probable dementia was confirmed on all participants by cognitive assessment results using Addenbrooke's Cognitive Examination (ACE). Inclusion criteria were fluent English language skills, no severe psychiatric disorder (e.g. schizophrenia) and no hearing or language impairment that would prevent communication or ability to hear music. We approached the residential aged care facility manager who provided a list of 44 names of individuals who matched these criteria. The potential participants' family members were then contacted, fourteen of whom declined to participate. Thirty participants were then visited individually at the residential facility to determine their suitability and interest in the program. Ten participants refused to participate leaving a final sample of 20. These 20 participants then completed baseline assessments.

The 20 participants were divided into two groups for logistical reasons. Group 1 completed the whole MMM program first and Group 2 completed the program second (immediately after Group 1), with Group 2 acting as a 'waitlist control'. The demographic and clinical characteristics of the participants are presented in Table 2. The clinical diagnoses were obtained from the medical records at the residential facility. In 10 out of 20 participant records there was no formal diagnosis of dementia noted. However, the ACE scores revealed that all participants met the cut off for probable dementia. The two groups were well matched in their clinical diagnoses in that they had various dementia types and there was one participant in each group diagnosed with Parkinson's disease and associated dementia (see Table 1).

Table 1. Demographic and clinical characteristics of the two groups of participants (n=20)

	Group 1 (n=10)	Group 2 (n=10)
Age (years)	84.4 (7.1)	82.20 (8.0)
Gender (M/F)	3/7	1/9
Education (years)	16.0 (0.9)	15.11 (1.0)
Time at residential facility (months)	27.2 (20.2)	18.20 (18.5)
Musical background (yes/no)	4/6	4/6
Clinical diagnoses (number of participants)		
Alzheimer's dementia	3	2
Vascular dementia	2	1
Mild cognitive impairment	0	2
Memory disturbance	4	2
Other	1	3

Note: Data presented as mean (standard deviation) unless otherwise stated.

Memory disturbance specified as 'amnesia', 'memory changes/issues', 'short term memory loss' on medical records.

Other specified as mood disorders, Parkinson's disease, depression.

2.3. Conditions

2.3.1. The MMM Program

The MMM program focusses on incorporating music-based activities which highlight all seven capacities of music. The capacities represent distinct qualities of music and the outcomes are the benefits that arise as a consequence of tapping into these capacities in the relative areas of decline, such as cognitive, behavioral, motor and identity, as outlined in the TMCM (see Figure 1). The MMM program encompasses activities that possess a specific set of 'active ingredients' to enrich the environment and maximize the activation of the seven capacities outlined in the TMCM and enhance their known benefits for dementia. We suggest that there are five active ingredients which apply to various activities in the MMM program:

a) Novel versus familiar (involve engaging with novel or familiar music)
b) Complex versus simple (involve complex or simple sequences of actions or verbal material, accompanied by music)
c) Intensity (quantity of each task)
d) Challenge (involving tasks that are slightly hard or easy to complete)
e) Empathy (tasks requiring forms of empathy, such as listening and putting themselves in the shoes of others)

Through the activities, participants are encouraged to play simple instruments (such as bucket drums and egg shakers), sing, move and interact with one another.

Table 2. MMM sessions and their targeted capacities, active ingredients and outcomes.

	Session 1 & 2	Session 3 & 4	Session 5 & 6	Session 7
Capacities	*Engaging* and *persuasive*	*Emotional* and *personal*	*Social*, *physical* and *synchronization*	*ALL attributes*
Active ingredient	Novel vs familiar, simple vs complex, empathy	Familiar, empathy	Familiar, simple vs complex, intensive	Intensive, familiar
Example activities	*Novel & Complex:* i) Introducing each musical instrument with songs (egg shakers, drums) ii) Learning names and personal description to melodic and rhythmic framework *Familiar* i) Game: Guess that advertisement's song (and singing along) *Novel & Empathy* i) Game: Which advert jingle is more convincing? (discussing how music makes adverts convincing) ii) Game: Where does this song belong? (guessing the context of the song and discussing why it fits there)	*Familiar* i) Game: Who sang that song? (guessing the name of artist and song) ii) Finish the next line of the song lyrics (singing along to favorite songs and guessing the missing lyrics) *Familiar & Empathy* i) Reminiscence with music (play each individual's favorite sons and discuss memories evoked) ii) Game: Guess which movie the soundtrack belongs to? iii) Music and our emotions (playing to express emotions and how you are feeling)	*Familiar & simple* i) Warm up movement exercises; start with slow songs (e.g., "My Bonnie") and progress to faster (e.g., "In the Mood") *Familiar, complex, intensive* Musical instrument playing (moving and making music in synchrony, turning to face partners and exchanging instruments and making eye contact). *Novel* Game: Match the dance song to the photo (discuss why the music fits with each song)	*Intensive & Familiar* Selected activities from other sessions (e.g., reminiscence, singing, playing along and engaging socially).
Outcomes	*Cognitive* (memory and attention	*Psychosocial* (mood and identity)	*Motor* (verbal and movement fluency)	All

2.3.1.1. Sessions

We devised seven weekly sessions broken into four blocks and each block contained activities that focussed on two or three related capacities of music (a summary of the activities can be seen in Table 2). The four blocks were designed to determine the relative contribution of each individual or combination of comparable capacities on specific outcomes, for example, the contribution of the personal and emotional capacities of music (Session 3 and 4) related to the outcome of 'mood' and 'identity' (Table 2).

Block one (sessions one and two), focussed on the *persuasive* and *engaging* attributes which may aid processes of attention and memory. The active ingredients in these sessions are 'novel' versus 'familiar', 'simple' versus 'complex' and 'empathy'. For example, in the first session tasks start relatively simply, as the participants are trying to complete verbal tasks to novel musical structures (e.g., how melody and rhythm can be used to help to remember verbal information, such as names or short phrases). Participants are invited to listen to how messages in familiar advertisements are highlighted and enriched by music, making them extremely memorable.

Block two (sessions three and four) focussed on the *emotional* and *personal* attributes. The active ingredients in these sessions are 'familiar' and 'empathy' to stimulate benefits in mood and identity. Familiarity is emphasised by including the participants' personally selected favourite songs as well as songs from their reminiscence bump period. The aim of this block is to encourage reminiscence and discussion about personal memories and to stimulate emotions through playing and listening to music, embodying empathy.

Block three (sessions five and six) emphasised the *social*, *physical* and *synchronous* attributes. The active ingredients in this session are 'familiar', 'simple', 'complex' and 'intensity' to stimulate positive change in both motor and verbal fluency. For these sessions, we used familiar music that had a strong beat and paired it with movements to promote physical activity. Participants were encouraged to play their instruments in synchrony with each other and to engage socially whilst doing so (such as turning to the person beside them). Rhythmical phrases played in time to the music started off simply, to allow participants to gain a sense of mastery, and in time became more complex.

Block four (session seven) drew upon all the capacities and involved live music. The active ingredients in this session were 'intensive' and 'familiar', as it is the last session. Musicians from the local Conservatorium of Music played the residents favourite songs. Live music can be especially engaging for participants and playing preferred and familiar songs may help to bring back personal memories and provide a rich emotional experience. During this session, participants were encouraged to respond to the music with physical movements and singing along, allowing them to synchronize their movements and voice with the music and with other participants, ensuring that they would have a powerfully social experience.

2.3.1.2 Music choice

Before starting the program, the researchers asked the participants for at least one or two favourite songs, artists or genres of music. This was primarily for the reminiscence sessions in Block 2. All other music used in the sessions was from the participants reminiscence bump period (aged 10-30 years). This would ensure the participants would be highly familiar with the songs and the personal nature of the program would be maximised. A list of songs used in the program can be found in Appendix A.

2.3.1.3 Musical instruments

Each participant had a bucket drum (a bucket turned over), two drum sticks and an egg shaker set up in front of them at the start of each session. The researchers ensured they were easily accessible (for example, if the participants had trouble reaching the bucket drum two or more buckets were stacked on top of each other).

2.3.1.4 Program set-up

The duration of each session was approximately 45 minutes. This allowed approximately 10 minutes for each activity (see Table 1). The sessions took place in a medium sized room at a residential aged care facility. Power-point slides were devised to both prompt the researchers and show pictures and videos to the residents (mainly for sessions 1-4). Participant chairs were set up in a semi-circle to face the projector screen where the power-point slides were displayed. The intervention was conducted by two researchers. Researcher two (R2, JC) had experience with prior group music programs in schools and elderly care, and facilitated all sessions. The second researcher (R1, OB), assisted by encouraging discussion and ensuring all participants had the relevant musical instruments. The third researcher (R3, AB) was present for Group 1 and had a similar role to R1. One researcher would typically sit at the front by the projector screen and the other approximately half way around the circle to facilitate a social environment.

Approximately half of the participants required wheelchairs for transportation to and from the venue and stayed in the wheelchair during the sessions. These participants demonstrated a minimal to medium range of motion and were able to move upper and lower limbs voluntarily.

2.3.1.5 Booster Sessions

On a separate day after each group session, R2 visited each participant individually for 10-15 minutes as part of the 'Booster Sessions'. The booster sessions were designed as a way to increase dosage and allow the participants to reflect on their experience of the previous session. R2 would first ask the participants a series of open-ended questions pertaining to whether they remembered the previous MMM session, and if so, did they enjoy it and specifically what they enjoyed about it. R2 then engaged the participant in completing two activities that were covered in the previous session as a "refresher" for the participant.

2.3.2 Standard care group (SC condition)

Group 2 served as a waitlist group for 7 weeks and did not participate in any prescribed program, whilst continuing with their standard care and activities until their follow-up assessments. Activities that were available to them by the residential aged care facility on a weekly basis were group discussions, miniature bowling, physical exercise, 'name that tune' and craft. Nine out of the 10 participants answered a series of yes/no questions to determine their level of activity during this period of time; 2/9 participants said they participated in physical exercise; 5/9 participants said they engaged in social activities; 3/9 participates said they sang regularly; 6/9 participants said they listened to music regularly and 0/9 participants said they played a musical instrument currently.

2.4 Design

The study design is illustrated in Figure 2. Group 1 completed the MMM program first, whilst recruitment of Group 2 took place. Group 2 then served as a waitlist control, with a period of no intervention during which they received standard care (SC) only. Group 2 then completed the MMM program immediately after Group 1. Assessments of cognition, mood, identity, verbal and motor fluency were taken at baseline (1 week prior to program/waitlist start, T1) and at a follow-up immediately after the program/control (T2). For the MMM condition only, assessments were also taken at an extended follow-up one month after participation in the MMM program (T3).

A subset of the measures (brief assessments for a total duration of 5 minutes) were taken at the end of the last session of the three MMM blocks (in week 2, 4 and 6). This was designed to assess the distinct effect that each of the seven attributes might have on specific domains of functioning. Baseline assessments of Group 1 were performed by authors 1 and 3 (R1 and R3; OB and AB respectively). Baseline assessments of Group 2 were performed by an independent researcher, blind to participant group membership, who also conducted all other follow-up assessments for both groups (excluding Group 2 follow-up SC assessment, due to logistic restrictions which were done by R1 who was blinded to the original baseline assessment scores).

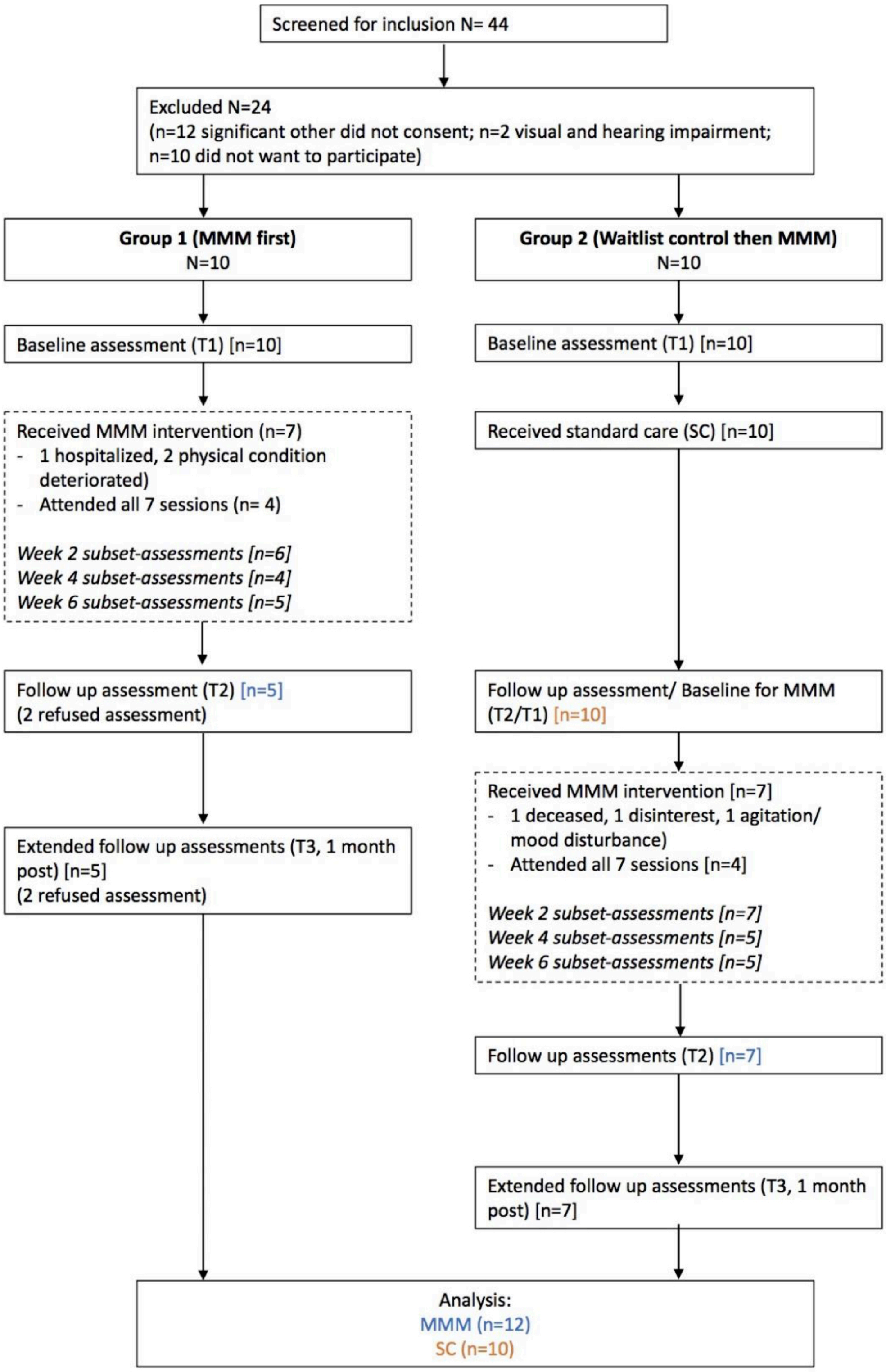

Figure 2. Flow chart of the study design.

CHAPTER 3

2.5 Measures

2.5.1 Cognitive function: Addenbrooke's Cognitive Examination (ACE) Australian Version III

The ACE is a cognitive measure used in screening for dementia and developed as a "theoretically motivated extension of the Mini-Mental State Examination (MMSE)" (Mathuranath, Nestor, Berrios, Rakowicz & Hodges, 2000; Mioshi, Dawson, Mitchell, Arnold & Hodges, 2006). Cut-offs at 88/100 (sensitivity = 94%, specificity = 89%) and 82/ 100 (sensitivity = 84%, specificity = 100%) for the suspicion of dementia have been defined. The ACE has very good reliability (alpha coefficient=0.8).

The ACE tests five subdomains of cognitive skills: attention (/18), memory (/26), verbal fluency (/14), language (/26) and visuospatial skills (/16) with a total score out of 100. The subdomain of attention tests the participants' ability to: recall the date, the current season and location, repeat back immediately three simple words and serial subtraction. The memory items first test the participants' ability to: recall the three simple words, then asks them to verbalise them, memorise and recall a fictional name and address, and remember several well-known historical facts. Fluency tests the ability to: list as many animals they can in one minute, followed by as many words they can beginning with the letter 'P' in one minute. The language subdomain requires the participant to: complete a series of physical tasks that are verbally directed by the researcher using a pencil and piece of paper (e.g. "pick up the pencil but not the paper"), write two complete sentences, repeat four complex words and two short proverbs, name 12 simple drawings of objects and animals, answer four semantic questions relating to the drawings, and read aloud five words that are easily mispronounced. Lastly, the visuospatial abilities subdomain tests participants' ability to: copy two figures, draw a clock face and the hands set at a particular time, count multiple dots in a square and recognise four partially obscured letters. Questions in the attention, memory and verbal fluency domains were also taken at the end of week 2, and verbal fluency domain at the end of week 6.

2.5.2 Mood: Geriatric Depression Scale Short-form (GDS-SF)

The GDS-SF has been used to screen for depression in the elderly (Sheikh & Yesavage, 1986). It was initially developed as a 30-item tool but the short form (15-item) was established for use in time constraints. The GDS-SF has been reported to be sensitive to depression in people with dementia. Scores greater than 5 points suggest depression and scores greater than 10 are almost always depression. It has good sensitivity (92%), specificity (89%) and high correlation ($r = .84$, $p < .001$).

2.5.3 Self-Identity: ‘I am/I was’ task

In the original form of this task (Rathbone, Moulin & Conway, 2008), participants are asked to list 10 ‘I am’ statements that strongly define their identity (e.g. “I am a grandfather”, “I am shy”). They are then asked to select the three most relevant statements and recall a personal memory that is linked to each one. For this study, the task was modified to involve the participant listing as many ‘I am’ and ‘I was’ statements as they could in 1 minute per category (e.g. “I was a dancer”, “I was a nurse”) in order to measure the participant’s change in identity over time. We also omitted the task of recalling memories associated with the statements and adapted the task for people with dementia by asking them to list the statements verbally rather than in written form, similar to that of Gridley, Brooks, Birks, Baxter and Parker (2016). This task was also repeated at the end of week 4.

2.5.4 Autobiographical memory fluency: Autobiographical fluency task (AFL)

In the original version of this task (Dritschel, Williams, Baddeley & Nimmo-Smith, 1992), participants are asked to recall list personal events and names of friends/acquaintances from different lifetime periods: ages 5-11years, 11-17 years, 5 years post high school and currently. They are given 90 seconds for each stage of life and each category (events and names). For this study, we omitted the events category and asked participants to list names only. This task was also repeated at the end of week 4.

2.5.5 Motor fluency: Nine-hole pegboard task

This task was initially introduced by Kellor, Frost and Silberberg (1971) and is used to measure finger dexterity in neurological disorders, particularly stroke and Parkinson's disease. Participants were timed on how long it takes to insert all 9 pegs one by one into the holes and remove them one by one. Measurements were taken for both the dominant (self-reported preferred writing hand) and non-dominant hands. This task was also repeated at the end of week 6.

2.6 Data analysis

Data analysis was completed using SPSS. Due to the structure of the study, we were unable to perform independent group comparisons between the SC condition and MMM condition as the MMM condition was made up of participants from Group 1 and 2. Assumptions of normality were met for the primary outcome variables using the Shapiro Wilk test. Thus, the analysis was conducted as a within group analysis, using paired t-tests within the SC condition and MMM condition. We compared the outcome measures (cognition, mood, self-identity, autobiographical memory fluency and motor fluency) within the MMM condition and SC condition at T1 versus T2 and T2 versus T3 (MMM only) to determine the effect of the MMM program overall.

We also sought to determine the distinct contribution that each of the seven capacities had on a subset of outcome measures. To do this we conducted pairwise comparisons of assessments taken at baseline and 'test' phase (either week, 2, 4 or 6 of the MMM program). At the end of week 2 (following sessions focussing on engaging and persuasive capacities) assessments consisted of subsets of cognition (attention, memory and verbal fluency). At the end of week 4 (following sessions on the personal and emotional capacities), assessments consisted of tasks assessing autobiographical fluency (AFL) and identity ('I am/I was' task). Finally, at the end of week 6 (following sessions on the social, physical and synchronous capacities) assessments consisted of motor fluency (peg hole task) and verbal fluency tasks.

The answers provided by the participants to the open-ended questions during the booster sessions were categorised into each of the seven capacities of music. This was completed by R1, according to the key words the participant used to describe what they enjoyed. For example, if participants said that they "enjoyed moving to the music" this was categorised into the *physical* capacity. If participants stated that they "enjoyed talking with one another" or "being a part of something" this was categorised into the *social* capacity. The categories of the seven capacities of music were not mutually exclusive, as some responses included many key words describing several capacities. For example, some participants stated that they "enjoyed talking about old memories, with everyone and hearing their stories" this was classified as *personal* and *social.*

CHAPTER 3

3. Results

3.1. Group Characteristics

There were no significant differences between the Group 1 and Group 2 in age, gender, level of education, or musical background (whether they had spent time learning an instrument or singing, see Table 1).

3.2. Drop-out rates

Figure 2 shows the drop-out rates per week for the MMM intervention and the associated reasons. In Group 1, 7/10 participants completed the MMM program and in Group 2, 7/10 participants also completed the MMM program. Regarding post program assessment, in Group 1, 5 participants were included in the analysis. In Group 2, all ten participants completed assessments pre/post the waitlist period of standard care and all seven participants who finished the MMM program completed post assessments. Thus, analyses of cognition, mood, identity and fine motor skills at T1, T2 and T3 were conducted on 12 participants in the MMM condition and 10 participants in the SC condition.

We compared the participants that dropped out of the MMM condition with those who completed the intervention on several potential influencing factors such as age, duration of residing at facility and total ACE score (pre MMM intervention). There were no significant differences between those that dropped out and those who completed the intervention on any of these measures.

3.3. Cognitive function

Table 3 shows results for total scores and subdomains scores of ACE for participants in the SC and MMM conditions. We examined both the total ACE scores and the ACE subdomain scores for the period of standard care (n=10) and for the MMM program (n=12), comparing the scores at T1 versus T2, and T1 versus T3 (for MMM condition only).

There was a significant decrease in the mean total ACE score for participants in the SC group from T1(59.40) to T2 (55.20), $t(9) = 2.29$, $p = .047$. For participants in the MMM condition, there was a marginally significant increase in mean total ACE score from T1 (57.00) to T2 (60.58), $t(11) = -2.11$, $p = .059$ (Figure 3). When examining individual participants in the MMM condition we found that 8/12 had an increase in total ACE scores after the intervention, and the remaining 4 participants had a decrease.

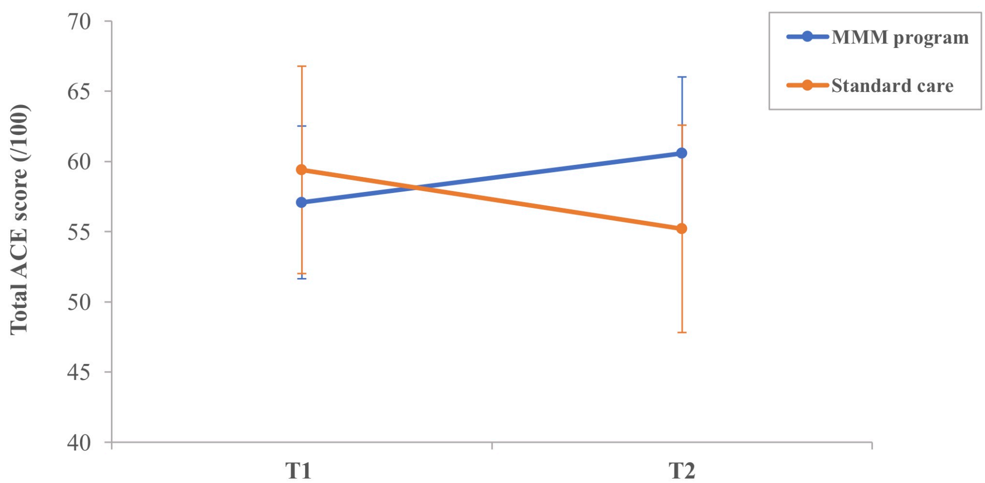

Figure 3. Mean total ACE score for participants in the MMM (n=12) and Standard care (n=10) conditions at T1 (time 1, baseline) and T2 (time 2, follow-up), (error bars= mean ± standard error of the mean).

At the extended follow up assessment (T3), there was also an increase in mean total ACE score from T1 (57.00) to T3 (60.50) after the MMM program, but this difference did not reach statistical significance, t (11) =-1.71, *p*= .115.

Separate t-tests on the ACE subdomain scores revealed there was no significant change in attention, memory, fluency, language or visuospatial ability scores from T1 to T2 in the SC condition. In contrast, participants in the MMM program showed a significant increase in 'attention' scores from T1 (10.67) to T2 (12.92), t (11) =3.45, *p*= .005. There was also a significant increase in 'verbal fluency' scores from T1 (4.33) to T2 (5.58), t (11) =2.21, *p*= .049 (Figure 4).

Comparisons of the ACE subdomain scores between baseline (T1) and the extended follow-up (T3) for participants in the MMM program revealed there was a significant increase in 'memory' scores from 12.08 to 14.08, t (11)=2.51, *p*= .029. There was no significant difference in the other subdomain ACE scores of attention, verbal fluency, visuospatial skills or language between these time intervals (T1 and T3). When observing individual participant changes in total ACE scores from T1 to T3 in the MMM condition, we found that 8/12 had an increase in score after the extended follow up, and the remaining 4 participants had a decrease.

Whilst the design of our study did not permit direct between- group statistical comparisons, Figure 4 illustrates the changes in the five ACE subdomains over the 8-week period for participants in the SC and MMM conditions. We can see that whilst participants in the SC condition decreased slightly in attention, memory and verbal fluency scores, participants in the MMM condition showed slight increases in these three subdomain scores. Both groups had a negligible decrease in language and visuospatial subdomains scores over the 8 weeks, with the SC group showing a slightly greater decline.

Table 3. Outcome measures, mean (SD), for standard care and MMM groups at T1(baseline), T2 (follow-up) and T3 (extended follow-up, MMM only).

	Standard care (n=10)		MMM (n=12)		
	T1	T2	T1	T2	T3
Total ACE score (/100)	59.40 (24.87)	55.20 (22.56)*	57.00 (16.64)	60.58 (18.85)	60.50 (18.54)
Attention (/18)	12.00 (4.83)	10.70 (4.42)	10.67 (3.20)	12.92 (3.20)**	11.42 (3.89)
Memory (/26)	14.20 (6.23)	13.40 (8.45)	12.08 (6.23)	12.75 (5.99)	14.08 (5.42)^
Fluency (/14)	5.80 (3.82)	3.90 (3.14)	4.33 (2.74)	5.58 (2.39)*	5.0 (2.92)
Language (/26)	18.70 (8.37)	19.40 (7.04)	20.58 (4.83)	20.42 (5.93)	20.5 (5.93)
Visuospatial (/16)	8.70 (4.44)	7.80 (3.88)	9.42 (4.38)	8.92 (4.29)	9.5 (3.87)
GDS-SF (/11)	5.33 (2.91)	5.89 (3.10)	3.83 (2.29)	4.17 (2.59)	3.33 (2.10)
Identity statements					
(total)	7.10 (3.48)	5.40 (3.06)	6.33(2.81)	6.67 (3.82)	5.92 (3.34)
‘I was’					
‘I am’	5.20 (1.75)	3.70 (2.83)	3.67 (2.71)	4.75 (1.71)	4.58 (3.31)
Autobiographical Fluency score (total)	12.00 (10.99)	10.50 (10.28)	9.92 (9.95)	10.75 (9.84)	10.58 (12.97)
Peg task (seconds)					
Dominant hand	53.58 (10.67)	69.89 (17.48)	58.3 (15.91)	56.84 (23.12)	49.93 (5.78)
Non-dominant hand	55.34 (16.03)	62.64 (12.43)	61.31 (10.09)	61.67 (21.61)	54.66 (10.98)

Note: Data presented as mean (standard deviation) unless otherwise stated.

* $p<0.05$ (T2 vs T1)

** $p<0.005$ (T2 vs T1)

^ $p<0.05$ (T3 vs T1)

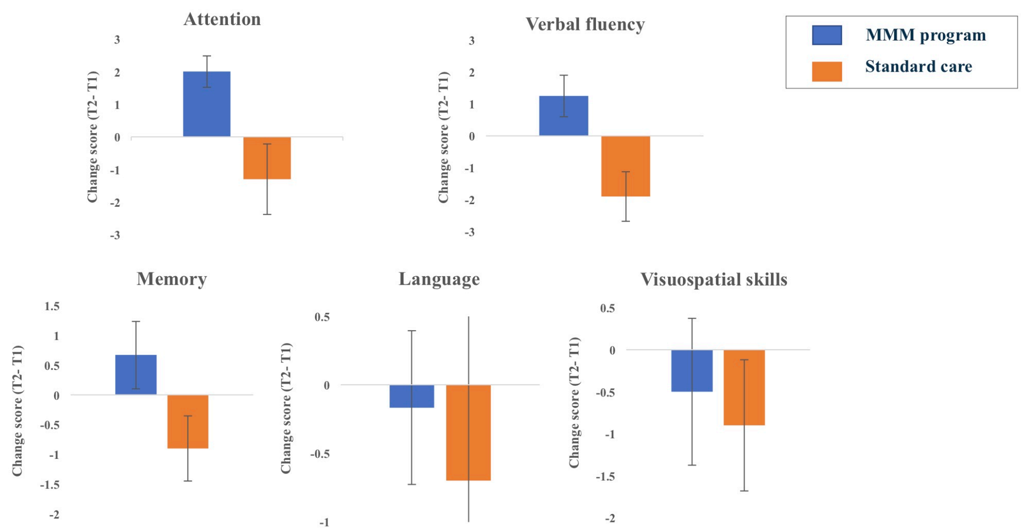

Figure 4. Changes in the five ACE subdomain scores from T1 (time 1, baseline) to T2 (time 2, follow up) for participants in MMM (n=12) and standard care conditions (n=10). (error bars= mean ± standard error of the mean).

3.4. Mood

The mean GDS-SF scores of participants in both the SC and MMM conditions remained stable between T1 and T2 and, T1 and T3 for the MMM group. In other words, there was no difference in reported depression symptoms before and after the period of intervention or standard care (see Table 3).

3.5. Self- Identity

All 20 participants were able to generate 'I am/I was' statements at T1. However, one participant, who had minimal expressive language at T1, was unable to generate any statements at T2 after the period of standard care. This participant later withdrew from the MMM program at week 2. The mean total number of 'I am' and 'I was' statements were analyzed separately. There were no significant differences in the mean number of 'I am/I was' statements between T1 and T2 in the SC or MMM condition, and T2 and T3 in the MMM condition (see Table 3).

3.6. Autobiographical memory fluency

For analysis purposes, the total number of names listed in each lifetime period was collapsed to create a total AFL score. There was no difference in the total number of names produced by participants in the SC and MMM conditions at T1 compared with T2, and T2 compared with T3 in the MMM condition (see Table 3).

3.7. Motor fluency

Within the SC and MMM conditions we compared the time taken (in seconds) for participants to complete the pegboard task with their dominant and non-dominant hand at T1 versus T2. In the SC condition, there was a trend for the time taken to complete the motor task to increase for both the dominant and non-dominant hands (from 53.6 seconds to 69.9 seconds, and from 55.3 seconds to 62.6 seconds, respectively), but these differences did not reach statistical significance. In the MMM condition, the time taken for participants to complete the task with the dominant and non-dominant hands remained stable from T1 to T2. For participants in the MMM condition, there was a trend for the time taken to complete the task to decrease, from 56.8 seconds (T2) to 49.9 seconds (T3), but this was not statistically significant (Table 3).

3.8. Relationship between demographic variables and cognition

We wanted to determine whether demographic variables (age, years of education and time in residency) predicted the change in cognition from T1 to T2, as measured by the total ACE score. To do this, we calculated a 'change score' by subtracting the total ACE score at T1 from the total ACE score at T2. We then conducted bivariate correlations to determine if there was a relationship between the demographic variables and the total ACE change score for participants in both MMM and SC conditions.

In the MMM condition, the participants' time in residency was negatively correlated with the total ACE change score, r= -.656, *p*= .020 (Figure 5). In other words, the longer the participant had been a resident at the aged care facility the less improvement in overall cognition after the MMM program. There was no significant correlation between the other demographic variables (age and years of education) and the total ACE change score. For participants in the SC condition, there was no significant correlation between any of the demographic variables (age, years of education and time in residency) and the total ACE change score.

We then further examined the significant negative correlation between participants' time in residency and the total ACE change score the MMM condition. We removed the participant with the longest duration of residency (52 months), their being an outlier by more than 2 standard deviations (see Figure 5). With this outlier removed, we then reanalysed the comparison of total ACE scores pre and post the MMM program. We found a statistically significant increase in total ACE scores from T1 (M=56.27, SD=17.25) to T2 (M=60.45, SD=19.76), t(10)= -2.4, *p*= .037, and from T1(56.27) to T3(M=61.18, SD=19.29), t(10)= -3.03, *p*= .013 for participants in the MMM conditions.

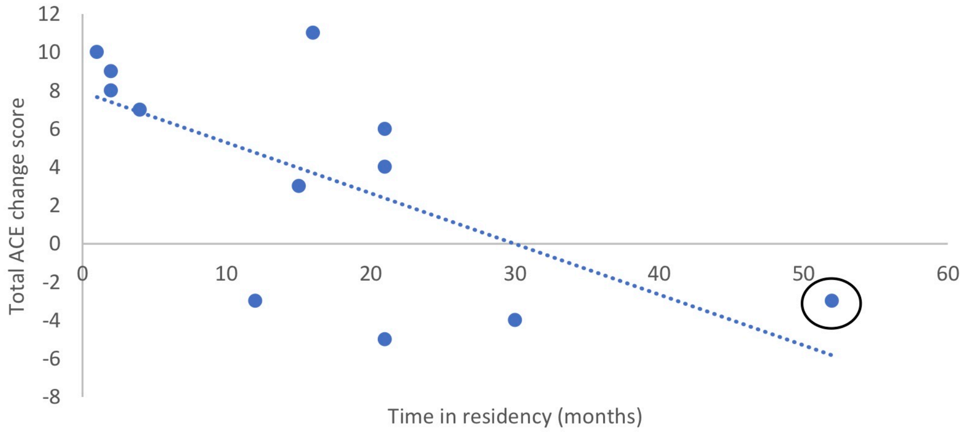

Figure 5. Relationship between time in residency and total ACE change score (T2-T1) after the MMM intervention (n=12). Outlier circled.

3.9. Prediction of attendance of MMM sessions

To examine predictors of session attendance in the MMM program we conducted Pearson correlations between the number of MMM sessions attended and the variables of age, time in residency and GDS-SF score. There was a significant moderate negative correlation between the number of MMM sessions attended and GDS-SF score, r= -.566, *p*= .009 (n=20). In other words, the higher the GDS-SF score (indicative of possible depression), the less MMM sessions attended (Figure, 6).

We then compared the GDS-SF scores of the participants who dropped out of the MMM program with those who completed the program. Those who dropped out of the MMM program had a higher GDS-SF score prior to the MMM program (7.33), suggestive of mild depression, compared to those who remained in the program, who had no indication of depression prior to the MMM program (4.21), t (18) =2.64, *p*=0.017.

Further, to determine whether the number of MMM sessions attended predicted the T1-T2 changes in total ACE and ACE subdomain scores, we conducted bivariate correlations. These analyses showed no significant correlations between the number of MMM sessions attended and the ACE scores.

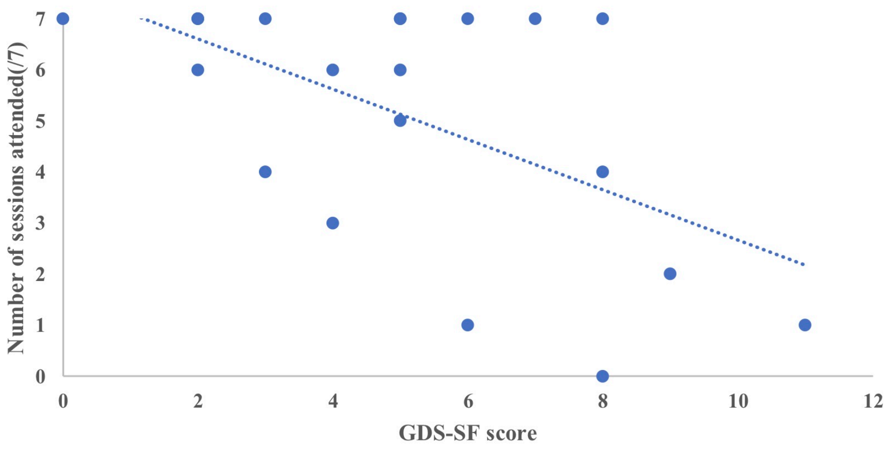

Figure 6. Relationship between the number of MMM sessions attended (maximum 7) and GDS-SF score prior to starting the intervention (n=20).

3.10. Assessment of individual seven capacities

To determine the distinct contribution that each of the seven capacities had on the subset measures we conducted pairwise comparisons between assessments taken at baseline and test phase (either week, 2, 4 or 6). Table 4 displays the assessments conducted at week 2, 4 and 6. Results showed that there were no significant differences between baseline and test phase on any of the subset of measures at week 2, 4 or 6.

Table 4. Subset measures, mean (SD), for MMM condition at baseline and test phase.

Measures	Baseline			Test Phase		
Engaging & persuasive	Attention (/8)	Memory- word list (/3)	Verbal fluency- letter (/7)	Attention (/8)	Memory- Word list (/3)	Verbal fluency-letter (/7)
(Week 2, n=12)	3.58 (1.83)	0.92 (1.16)	2.83 (0.39)	3.50 (1.38)	1.17 (1.11)	2.67 (1.50)
Emotional & Personal	AFL total	'I was'	'I am'	AFL total	'I was'	'I am'
(Week 4, n=11)	6.0 (5.06)	5.27 (2.57)	3.73 (2.24)	5.54 (4.76)	5.18 (3.06)	4.0 (2.0)
Physical, synchronous & social	Peg Task (Dominant)	Peg Task (Non-Dominant)	Verbal fluency-total (/14)	Peg Task (Dominant)	Peg Task (Non-Dominant)	Verbal fluency-total (/14)
(Week 6, n=10)	55.30 (23.45)	56.64 (15.07)	3.0 (1.43)	47.25 (10.20)	43.25 (12.51)	4.0 (1.45)

Note. AFL= Autobiographical Fluency task; Dominant= dominant hand; Non-dominant= non-dominant hand.

3.11. Subjective responses from booster sessions

The weekly booster session visits were made by R2 to 67.3% of participants who attended the corresponding MMM session. Figure 8 depicts the distribution of the participants' responses to the open-ended questions determining what aspects they enjoyed in the MMM program. The social capacity of music in the MMM program was the most valued by the participants, accounting for 36% of the responses. These responses included statements about enjoying the company of others in the group, making new friends, being in a group scenario, participating in discussions or ‘getting out of their room’. The engaging and personal capacities were the second most common theme of responses each accounting for 17% of the responses. These included statements about enjoying the experience of learning new things and the sounds of the musical instruments. Responses pertaining to the personal capacity included enjoying reminiscing and listening to their old songs. References to the emotional capacity of music were present in 13% of responses and included statements of feeling “lifted”, “happy” and “ready to party” after the sessions. Finally, 4% of responses included reference to the synchronous capacity of music and included statements such as doing two actions at one time. Other types of reflections accounted for 13% of all responses and included statements pertaining specifically to the MMM program, for example that it was “entertaining”, “something different’ and that the program was “delivered well”.

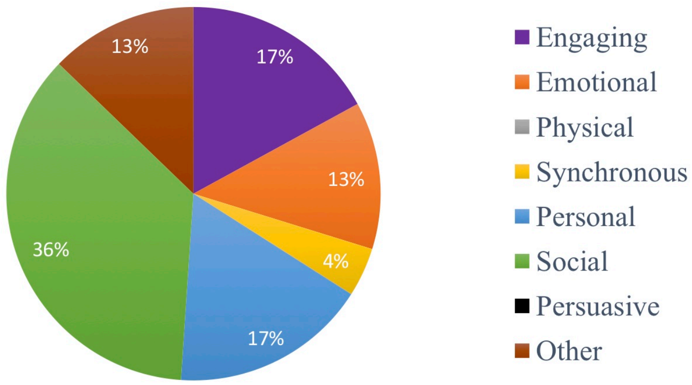

Figure 7. Distribution of the participants’ responses as to what aspects they enjoyed in the MMM program (Social, 36%; Engaging, 17%; Personal, 17%; Emotional, 13%; Other, 13%; Synchronous, 13%; Physical, 0%; Persuasive, 0%).

4. Discussion

We conducted a pilot MMM program for people with mild to moderate dementia (of various types) and examined its effects on cognition, mood, identity and fine motor function. The MMM program is group-based, comprising of seven weekly sessions broken into 4 blocks which draw upon the seven capacities of music in the TMCM (Figure 1). The main finding was that, compared with people receiving standard care who showed a decline in overall cognition over time, those who participated in the MMM program showed a slight improvement in cognition after seven weeks of participating in the MMM program. In particular, significant improvements occurred in the subdomains of attention and verbal fluency. In contrast, we did not find any change in mood, sense of identity or motor function after MMM participation. To our knowledge, the MMM program is the first music program based on a theoretical model underpinning the beneficial capacities of music for neurological impairment.

Our primary finding was the improvement of global cognition after the 7-week MMM program. This result is in keeping with previous studies which have shown that both music-based interventions and music therapy can improve or stabilise global cognition in people with dementia (Bruer et al., 2007; Cheung et al., 2018; Chu et al., 2014; Suzuki et al., 2004; Särkämö et al., 2014; Tang et al., 2018; Van de Winckel et al., 2004). Furthermore, our results showed that the improvement in cognition may also continue up to one month after the cessation of the program. This is in keeping with the findings of Chu et al. (2014) who found that cognition (as measured by the MMSE) did not decline at the one-month follow-up in participants with moderate to mild dementia after 6 weeks of music therapy. Our findings of improved performance in the specific cognitive subdomains of verbal fluency and attention are also consistent with previous research. Specifically, improvements in verbal fluency have been reported by Brotons & Koger (2000), Lyu et al., (2018), Van de Winckel et al., (2004) and Cheung et al., (2018). Särkämö et al., (2014) also found an improvement in general cognition and attention (as measured by the MMSE and Frontal Assessment Battery) after 10 weeks of either group singing or group music listening interventions. Taken together, these results suggest that a music program that involves actively applying seven crucial capacities of music is cognitively enhancing, particularly for verbal fluency and attention.

Importantly, our results also showed that the time in aged care residency predicted the degree of cognitive improvement that occurred after the MMM program. In other words, the longer a participant had spent in residency, the less general cognitive improvement they showed after MMM participation. Interestingly, post hoc analysis showed that by removing one participant who was an outlier with the longest time in residency, the comparison of participants' total ACE scores from T1 to T2 in the MMM group became statistically significant. This suggests that early engagement with the MMM program is most beneficial. Implementation of the MMM program in people with early stages of dementia may help to optimise cognitive function and delay admission to a residential aged care facility.

One mechanism underlying the beneficial cognitive effects we observed could be neural scaffolding, facilitated by the 'enriched environment' that the MMM program provided. Including all seven capacities of music music may have served to preserve the natural scaffolding process which was under threat by neurological impairment. The MMM program also incorporated activities which emphasised several 'active' ingredients, for example activities that were 'novel' or 'challenging', which may lead to 'scaffolding enhancement' (Park & Reuter-Lorenz, 2009). These active ingredients may facilitate neural scaffolding and improve cognition by placing the individual in a state of deep engagement. A similar phenomenon has been observed in other enriching group-based activities with healthy elderly individuals that involve learning novel and challenging skills, such as quilting or digital photography (Reuter-Lorenz & Park, 2014). Thus, the MMM program, through combining the multitude of therapeutic capacities of music, may provide the enriched environment needed for compensatory scaffolding.

We propose that these cognitive benefits of the MMM program can be attributed to the relative contribution of each of the seven capacities of music, activating neural networks and providing this compensatory scaffolding. Firstly, we utilized multiple music activities (singing, playing, moving) which may maximise widespread engagement of frontal, parietal, temporal, limbic/paralimbic and cerebellar brain regions. In particular, the cognitive effects may have been mediated through enhanced arousal, which facilitates attention and verbal fluency. Secondly, the task of listening to personal music evokes emotions and corresponds with neural activity in subcortical and medial regions (Koelsch, 2010). Simultaneously, the limbic and paralimbic regions, associated with the processing of emotions, are activated (Blood & Zatorre, 2001). As mentioned above, these limbic areas are relatively spared from degeneration in AD and may be a hub for the intersection between music, memories and emotions (Jacobsen et al., 2015). The physical movement involved in the program may have increased temporal arousal, stimulating cognitive activity. Indeed, improvement in cognition in people with dementia has been found in similar studies looking at music and movement (Cheung et al., 2018; Satoh et al., 2014; Shimizu et al., 2017; Van de Winckel et al., 2004). Adding to this effect, playing rhythmical musical instruments in a social setting allowed individuals to synchronize with the music and also with each other, which may have stimulated neural activation in the prefrontal cortex and improved cognition (Shimizu et al., 2017). Lastly, the potential therapeutic benefits of the program were enhanced by the persuasive nature of music. Participants retained the motivation to keep attending the MMM program as they experienced it as being an enjoyable activity, demonstrated by their qualitative statements of the sessions being ‘social’ and ‘engaging’. In this therapeutic setting, their enjoyment lead to increased motivation for participating in treatment. Thus, by involving all seven capacities of music and placing individuals in an enriched setting, the MMM program may maximize the potential of stimulating compensatory neural scaffolds.

Our finding of a decline in global cognition from participants in the standard care condition is consistent with other research findings. For example, Tang et al. (2018) reported cognitive decline in people with dementia following standard care in a nursing home facility over 12 weeks. They attributed this decline to apathy. The high occurrence of social withdrawal and isolation in people with dementia may be related to higher levels of apathy, which is associated with cognitive impairment (e.g. Benoit, et al., 2012). Whilst the individuals in the standard care group had the option of many activities to attend (provided by the residential aged care facility), these activities did not involve all seven capacities of the MMM program involved. Furthermore, many individuals did not attend the activities available. Therefore, this lack of stimulation may account for the decline in cognition. Not participating in stimulating activities later in life may hasten the decline in cognition that typically arises in aging as a result of age associated disuse (Mahncke, Bronstone & Merzenich, 2006).

In addition to cognition, we also assessed identity, mood and motor function. Whilst music is commonly linked with identity in dementia (Baird & Thompson, 2018; McDermott, Orrell & Ridder, 2014), this is the first study, to the best of our knowledge, to undertake an empirical investigation of this issue to examine the effect of a music-based program on identity in people with dementia. We found no significant change in our identity measure (using the 'I am/I was' task) after participation in the MMM program. These identity measures may not have been sensitive enough to capture changes that may have been more subtle or qualitative in nature. These constructs may have been better captured by interviews, as shown in previous research in group singing for people with dementia (e.g., Camic, Williams & Meeten, 2013; Osman, Tischler & Schneider, 2014).

To assess mood, we used a standard measure of depression specifically designed for elderly populations (GDS-SF). Unlike other similar studies that have reported improvement on this measure after participation in music activities (e.g., Cooke, Moyle, Shum, Harrison & Murfield, 2010; Guétin et al., 2009), we did not find significant differences between standard care and MMM groups. We would have expected that the assessments of mood may have reflected the subjective feedback about feeling 'happy' and 'elated' after the MMM sessions. We did, however, observe a significant correlation between number of sessions attended and level of depression (total GDS score). Thus, the no change observed in mood could be a dosage related finding, in that the participants who reported lowest mood at the start of the program attended the least amount of MMM sessions, meaning they did not get the full benefit of the entire program. These results also highlight the significance of how comorbidities prior to the start of a therapeutic program, such as depression, may reduce session attendance; stunting the potential for rehabilitation.

Participants responded well to the program and were able to participate in all activities. Using participants' subjective responses from the booster sessions, we can determine that the most enjoyed and valued aspects of the program were its social, engaging, personal and emotional nature. Through the semi-formal interviews and observations during the sessions, we found that discussing personal memories, emotional reactions to songs and also moving in time with one another enables the creation of social connections. This reinforces the value of conducting music-based interventions in a group scenario. Similarly, participants enjoyed listening to their personally chosen songs and those chosen by the other members, and reminiscing. Furthermore, we deemed the visit in Session 7 from the student-musicians from a conservatorium of music an important aspect of the study that could be implemented more often in programs. This intergenerational aspect to the program could be a way to reduce stigma associated with dementia whilst also decreasing social isolation, as previously demonstrated by Harris and Caporella (2014).

We evaluated our program as a prospective designed observational cohort study. Participants were not randomised which may have created a sample bias by recruiting those who were already interested in music or engaged with music activities at the residential aged care facility. Hence our results need to be taken with caution. Our cohort of participants with dementia was a heterogeneous group in terms of dementia type. This was not ideal given the likely different responses that people with different types of dementia may have to music. Nevertheless, the heterogeneous nature of our sample means that the results may be generalizable to the wider dementia population. Despite the majority of participants not having a musical background, this did not impact on their ability to successfully engage in any facet of the MMM program. This demonstrates that anyone is able to participate in and receive benefits from the MMM program, even those with no prior music training. For logistical reasons, this pilot study was conducted with patients from a single residential facility. The main limitation is our small sample size, primarily due to attrition rates from illness, death, visitors and timing of sessions after lunch when many participants were tired and often slept. The fact that we were able show an improvement in cognitive function following a pilot MMM program justifies future and more methodologically rigorous research in larger sample sizes, using a randomised control trial design.

Further studies could evaluate the duration and dosage of such a program to potentially maximise the cognitive benefits of the MMM program. Although visiting each participant on a weekly basis may not be feasible by residential aged care facility staff, the improvement in cognition in our results indicated that potentially one full group MMM session plus an individual booster MMM session per week is valuable.

There is a need to explore the specific effects of each music attribute to further our understanding of the interplay between each capacity and its therapeutic outcome, as seen in the TMCM. Studies could also include comparisons of the MMM program to programs that focus only on specific attributes, such as music and reminiscence (emotional and personal) or music and movement (physical and synchronous), or those that are not based on any theoretical model. Further research could also compare the MMM to other arts-based programs, to determine whether music is unique and special in its effects, or whether the social nature of group activities is what is driving the benefits (as seen in Narme et al., 2014 who found no short-term behavioral differences between music and cooking).

Finally, the MMM program could be trialled with people with other neurological disorders such as Parkinson’s disease and stroke. In our cohort of participants, we had two individuals with Parkinson’s disease and one with post stroke aphasia. These individuals were able to participate in all activities in the MMM program to the same extent as the participants with dementia.

CHAPTER 3

4.1 Conclusion

In conclusion, the present study is the first to devise and test a music-based treatment that is grounded in a model of the therapeutic application of music, the TMCM. The significance of the MMM program lies in the link between the program's activities and the specific mechanisms. This not only furthers our understanding of music-based treatments but also, unlike other protocols, addresses individual goals, as therapists can emphasise specific activities that have been empirically linked to target problems faced in neurological disorders. Our results demonstrate that the MMM program may benefit cognition, particularly attention and verbal fluency, in people with various types and severity of dementia. By including all seven capacities of music in one treatment, individuals were placed in a particularly enriched environment likely to promote neural scaffolding. Our findings highlight the importance of engaging people in such programs soon after admission to a residential aged care facility (or even earlier) to gain optimal cognitive benefits. The small sample size and the heterogenous nature of the sample calls for other studies to be conducted to determine the reliability of these effects. Nevertheless, these findings advocate the development of music-based treatments based on a theoretical model, such as the TMCM, which provides a framework for personalised treatments for people with dementia.

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Author contributions

OB and AB coordinated testing and data collection. OB was responsible for data analysis and all authors contributed to data interpretation. OB wrote the first draft of the manuscript and all authors contributed to further revisions. All authors approved the final version of the manuscript and contributed to the design and development of the study.

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Conflict of Interest

The authors declare that there is no conflict of interest.

CHAPTER 3

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CHAPTER 3

Appendix A:

List of songs

1. Glen Miller- In the Mood
2. Glen Miller- Chattanooga Choo Choo
3. Judy Garland- Somewhere Over the Rainbow
4. Gene Kelly- Singing in the Rain
5. Nat King Cole- Too Young
6. Doris Day- Que Sera Sera
7. Doris Day- Black Hills
8. Dinah Shore- Buttons and Bows
9. Bing Crosby & The Andrews Sisters- Don't Fence Me In
10. Bing Crosby- Swing on a Star
11. Bing Crosby- White Christmas
12. Perry Como- Catch a Falling Star
13. Frank Sinatra- Come Fly with Me
14. Little Eva- The Locomotion
15. Buddy Holly- Peggie Sue
16. Sam Cooke- Cupid
17. Ella Fitzgerald- A-Tisket, A-Tasket
18. Bill Haley and his Comets- Joey's Song
19. Elvis-It's Now or Never
20. The Beatles- Hey Jude
21. Some Enchanted Evening
22. My Bonnie Lies over the Ocean

Chapter 4:

The personal and emotional capacities of music in stimulating autobiographical memories

Chapter 3 revealed that a music-based program based on the TMCM that incorporated all seven capacities of music may be effective at improving cognition in people with dementia. A central aim of this thesis was to determine the relative importance of individual capacities of the TMCM for cognitive, psychosocial, motor and behavioural functions. Based on observations during the MMM program in the sessions that focussed on the ‘emotional’ and ‘personal’ nature of music, we hypothesised that these two capacities may be particularly important in stimulating autobiographical memories. Previous literature has established the link between personal and emotional music, and the stimulation of autobiographical memories. However, given that people with dementia may not have a reliable insight into detailing their emotions, we wanted to observe this link using an objective measure, using the measurement of facial expressions as a marker of emotion. Thus, we devised a study examining smiles during the recollection of music evoked autobiographical memories (MEAMs) in people with Alzheimer’s dementia, whilst listening to 16 songs throughout the decade.

This current study was a follow-on study from that of Baird, Brancatisano, Gelding and Thompson (2018, Appendix III) in which we reported no difference in the frequency of MEAMs between healthy elderly and people with AD. We also reported that songs from when participants were aged 10–30 years (known as the reminiscence bump period) triggered more frequent autobiographical memories compared with stimuli from later decades in both healthy elderly and AD participants. The participant sample in the current study was the same individuals from the study by Baird et al., (2018, provided in Appendix III).

The manuscript that details the following study (manuscript 4) was co-authored with Amee Baird and Bill Thompson. My contribution to the manuscript was roughly 80%, which included experimental design, data collection, data analysis, and preparation of the first draft of the manuscript. Amee Baird administered the experimental task and provided assistance with the experimental design, the interpretation of results and comments on the manuscript. Bill Thompson provided helpful comments and suggestions on the manuscript.

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CHAPTER 4

Positive Facial Expressions are Associated with Music Evoked Autobiographical Memories in Alzheimer's Dementia

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Abstract

Despite memory impairment in Alzheimer's Dementia (AD), music evoked autobiographical memories (MEAMs) are comparatively preserved. Previous studies have identified the self-rated positive experience of MEAMs and that songs from the participants' 'reminiscence bump' time period (10-30 years of age) are particularly effective at triggering MEAMs. In this investigation, we explored whether MEAMs are accompanied by smiles, and whether songs from the reminiscence bump are more likely to trigger smiles than songs from later decades. Ten healthy elderly participants and nine people with AD reported memories following exposure to 16 songs from 1930 to 2010. Smiles were rated by 3 independent judges. Both healthy elderly and AD participants produced a significantly higher proportion of smiles when they reported a MEAM, with no significant differences between AD and healthy elderly participants in the frequency of smiles during MEAMs. However, only in the AD participants was there a higher proportion of smiles during songs from the reminiscence bump time period, and a higher proportion of smiles during MEAMs from songs from their reminiscence bump time period, compared with songs from other decades. These findings contribute to the understanding of the relationship between music, emotion and autobiographical memory in both healthy and dementia populations.

Key words: music, emotion, memory, Alzheimer's Dementia.

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Introduction

Alzheimer's dementia (AD) is the most common form of dementia and occurs as a result of Alzheimer's disease, in which amyloid-beta plaques and neurofibrillary tangles cause the degeneration of brain cells. This deterioration precipitates cognitive decline, primarily in memory functions, including autobiographical memory (e.g., Addis & Tippett, 2004; Ivanoiu, Cooper, Shanks & Venneri, 2006; Seidl, Lueken, Thomann, Geider & Schroder, 2011; El Haj, Antoine, Nandrino & Kapogiannis, 2015). Autobiographical memory is crucial for building and maintaining our identity through the ability to reconstruct personal experiences and integrate knowledge of self traits (Conway & Pleydell-Pearce, 2000; Addis & Tippett, 2004; El Haj, Antoine, Nandrino, Gely-Nargeot, Raffard, 2015; El Haj & Antoine, 2017). This decline in the ability to recall autobiographical memories, contributes to a loss of identity and subsequently compromises well-being in people with dementia (Jetten, Haslam, Pugliese, Tonks & Haslam, 2010).

There is accumulating evidence that music can stimulate autobiographical memories in people with AD. There are numerous anecdotal reports of individuals with AD being 'awakened' by music and having autobiographical memories flood back to them, as shown in documentaries such as *Alive Inside* (Rossato-Bennett, 2014). Experimental studies have provided evidence that certain music is indeed a promising catalyst for facilitating autobiographical memory in people with AD (Foster & Valentine 2001; Irish et al., 2006; El Haj, Fasotti & Allain, 2012; El Haj, Postal & Allain, 2012; El Haj, Clément, Fasotti & Allain, 2013; El Haj, Antoine, Nandrino, Gely-Nargeot, Raffard, 2015; Cuddy, Sikka & Vanstone, 2015; Cuddy, Sikka, Silveira, Bai & Vanstone 2017; Baird, Brancatisano, Gelding & Thompson, 2018). Foster & Valentine (2001) showed superior autobiographical recall (using an adaptation of the Mini-Mental State Examination) in those with mild to moderate dementia during the playing of background music, compared with a background of noise or silence. This finding was replicated by Irish et al., (2006) who found that people with AD demonstrated an improvement in autobiographical memory (using the Autobiographical Memory Interview) during the playing of Vivaldi's *'Spring'* movement as opposed to during silence. Other studies have explored memories triggered by music, a phenomenon known as Music Evoked Autobiographical Memories or 'MEAMs'. Despite the decline in autobiographical memory function, several studies have shown that MEAMs are as frequent in people with AD as they are in the healthy population (Cuddy et al., 2015; Cuddy et al., 2017; Baird et al., 2018). Verbal descriptions of MEAMs by participants with AD have also been shown to contain higher grammatical complexity and more 'self-defining' references compared with memories evoked after a period of silence (El Haj, Fasotti & Allain, 2012; El Haj et al., 2013).

Two attributes of music are especially significant in the association between music and autobiographical memories; music is *emotional* and *personal,* as identified in the *Therapeutic Music Capacities Model* (for a review see Brancatisano & Thompson, in press). The emotional and personal capacities of music may act together, fortifying a relationship between music and autobiographical memory.

To begin with, the capacity of music to induce *emotion* is one of the primary reasons we listen to it. It may also explain why we are able to remember pieces of music and their associated preserved memories over a long period of time (Krumhansl, 1997; Pansepp, 1995). There are strong neurological and psychological associations between memory and emotion, such that they are often tethered to each other in human experience (for review see, Philippot & Schaefer, 2001). One question that arises within this literature is whether enhanced autobiographical memory performance is mediated by emotion, or whether an emotion is a product of the autobiographical memories triggered. Perhaps the fact that these psychological phenomena mutually reinforce each other is what creates the strong link between music and autobiographical memory. The first explanation is that the music triggers an emotion and this emotional state makes people more susceptible to the evoking of an autobiographical memory. The enhancement of autobiographical recall from music has been attributed to emotional mechanisms including arousal enhancement (Foster & Valentine, 2001) and anxiety reduction (Irish et al., 2006). Songs that are highly emotional are regarded as particularly effective at evoking autobiographical memories (Bower, 1981). Hearing an emotional piece of music engages widespread brain regions, including the limbic system, which is responsible for emotions as well as memories (e.g., Blood & Zatorre, 2001). Janata, Tomic and Rakowski (2007) observed that songs that produced MEAMs in university students were typically associated with strong, positive emotional experiences such as nostalgia. Thus, the way in which music triggers positive emotions is considered as an arousing and positively valenced event, and subsequently acts as a memory enhancer (for a review see Jäncke, 2008).

Another explanation is that the music triggers autobiographical memories which themselves are the catalyst to emotions (Juslin & Västfjäll, 2008; Juslin, Harmat & Eerola, 2014). Juslin and colleagues consider that one way in which music induces emotion is through the evoking of episodic memories, whereby hearing a piece of music often brings back memories of a period of life, subsequently carrying the emotion experienced at that time. Previous studies have demonstrated that autobiographical memories triggered by music (compared with silence) contain more references to emotion (El Haj, Fasotti & Allain, 2012; Janata et al., 2007). Similarly, in people with AD, MEAMs have been self-rated as more positive and as impacting on their mood positively, compared to memories evoked in silence (El Haj, Fasotti & Allain, 2012; El Haj, Postal & Allain, 2012). Furthermore, both healthy older adults and individuals with AD have self-rated MEAMs as more positive than negative, known as the 'positivity effect' (Cuddy et al., 2017), and shown similar positive emotional responses, such as smiling and laughing to the musical excerpts eliciting memories (Belyea, Sikka, Chan & Cuddy, 2016).

The second proposed capacity of music that plays a role in its autobiographical memory enhancing effect is its *personal* nature. In healthy individuals and people with AD, personally chosen music has been shown to evoke memories that are particularly emotional and self-defining, compared to memories evoked by researcher-chosen music that may have no personal connection (El Haj, Postal & Allain, 2012; El Haj et al., 2013; El Haj, Antoine, Nandrino, Gely-Nargeot, Raffard, 2015). In addition, highly familiar songs (compared to those that are less familiar) have been shown to trigger memories that are self-rated as more emotionally positive, particularly in older adults (Ford, Rubin & Giovanello, 2016). The memory enhancing nature of personal music could in part be due to its connection with emotionally salient times in one's life. Specifically, songs from one's youth (when aged 10 to 30 years) have been shown to generate more frequent memories than songs from later decades, suggesting that music from this 'reminiscence bump' (RB) period is particularly evocative for autobiographical memory (Baird et al., 2018). The 'reminiscence bump' is a term given to the peak in memories from the lifetime period of ones' youth and considered crucial to the formation and stability of self-identity (Rathbone, Moulin & Conway, 2008). Memories from the RB are often described as extremely vivid, emotional and particularly self-defining (Schulkind et al., 1999; Conway & Holmes, 2004). Thus, music that is personally relevant is particularly effective at evoking autobiographical memories, which themselves lead to emotional experiences that are positive (Janata et al., 2007; El Haj, Fasotti & Allain, 2012; El Haj, Postal & Allain, 2012).

Studies to date have relied on the participants' subjective ratings of their emotions during MEAMs, and there has been no objective measure of emotions during MEAMs. In people with AD, self-report measures may be susceptible to problems of demand characteristics. Given the cognitive impairment in AD, facial expressions might provide an objective way of evaluating emotionality, without placing cognitive demands on the participants. Facial expressions convey the emotion experienced by an individual and are widely considered to be an ecologically valid physiological measure of emotion (El Haj, Antoine & Nandrino, 2016; Gandolphe et al., 2018). The analysis of facial expressions has been recently investigated in healthy individuals in order to understand the relationship between emotion and autobiographical memory (Gandolphe et al., 2018). El Haj et al., (2016) cued autobiographical memories by presenting healthy participants with emotional words such as "happy" or "sad". They analysed the participants' facial expressions using facial coding software (FaceReader) and found that the expressions corresponded with the correct emotional cue words (e.g., smiles during memories cued by the word "happy"). In another study, Gandolphe et al. (2018) used similar facial recognition software to detect a range of facial expressions of healthy participants during the retrieval of self-defining memories. They observed that self-defining memories occurred with more positive facial expressions (e.g., smiles) than negative expressions (e.g., sad, angry, disgusted). Importantly, the subjective emotional ratings of self-defining memories were shown to be consistent with facial expressions. Specifically, the positive facial expressions (e.g., smiles) corresponded with the participants' self- rating of the positive valence of the memories. We can therefore accept the use of facial expressions as a surrogate marker of the emotional subjective experience of autobiographical and self-defining memories.

Following on from this, the aim of the current study was to examine positive facial expressions to objectively measure the emotional characteristics of MEAMs in people with AD. More specifically, we were interested in examining the frequency of smiles in relation to MEAMs, particularly during songs that were more personally relevant (from the RB period) compared to those that were less personally relevant (from later decades). We also determining the timing of the emotional experience (before or after reporting a MEAM). Thus, we observed the presence of smiles during MEAMs in response to sixteen most popular songs throughout eight decades from 1930-2010.

Firstly, given the similarity between AD and healthy elderly participants in the emotional nature of MEAMs as mentioned in the above literature, we predicted that the frequency of smiles during MEAMs would be similar between people with AD and healthy individuals (H1). Secondly, we predicted that the proportion of smiles would be greater during songs that elicited MEAMs compared with songs that did not elicit MEAMs (H2). Thirdly, we hypothesised that given the highly emotional and personal nature of the RB period, songs from this lifetime period would be associated with a) more smiles compared with songs from the later lifetime periods (H3a) and b) more smiles during MEAMs that occur in response to RB songs than songs from later lifetime periods (H3b). We also addressed the relationship between the timing of emotion and memory (H4); if the MEAMs themselves induce emotion, we would expect the smiles to occur *after* the memory has been expressed. However, if the emotion induced by the music triggered the MEAM, we would expect the smile to occur *before* the memory was reported. Finally, we explored the relationship between the participants' subjective positive emotional ratings of memory and the presence of smiles (H5). To ensure that there was no confounds in the participants' demographic information or current mood state, we also examined the relationship between these factors and smiles.

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Methods

Participants

The participants included 9 individuals (4 males, 5 females) clinically diagnosed with probable AD, and 10 aged matched healthy elderly (6 males, 4 females). Dementia diagnoses were made by a Geriatrician and Clinical Neuropsychologist. The participants with AD were recruited via a regional health service in New South Wales, Australia, (n = 7) and an aged care facility in Sydney (n = 2). The healthy elderly participants were recruited via the Macquarie University Australian Research Centre of Excellence in Cognition and its Disorders research participant registry (n=9) and one family member of an AD participant.

Inclusion criteria were native English speaking and residing in Australia since age 10 years (to ensure familiarity with stimuli). During the assessment session, it was discovered that one AD participant had moved to Australia from Scotland at the age of 29, and one healthy elderly participant had moved to Australia from England at the age of 30. A comparison of these two participants' results with the others did not reveal any differences, and therefore their results were included. Exclusion criteria were a comorbid neurological condition (e.g., Parkinson's disease) or severe psychiatric disorder (e.g.,schizophrenia), and any visual, hearing or language impairments that would prevent communication or ability to hear music and engage with the stimuli. Two participants with AD still played a musical instrument while the remaining had no music training. No healthy elderly participants had any formal music training.

Materials

Song Stimuli

Sixteen famous songs were chosen (see Baird et al., 2018 for the list of songs) with two songs selected from each decade from 1930-2010. Songs that were selected had spent the longest duration at Number One in the Australian music charts and had the highest music sales according to two sources: The Kent Music Report (for songs from 1930-1989) and Australian Recording Industry Association (for songs from 1990-2010). Songs were purchased via iTunes and played on a laptop through a Bluetooth speaker.

Participant Energy, Mood and Tension Ratings

At the start of the session participants were asked, "How are you feeling right now?" in regards to energy level (1= very sleepy, 2= neither, 3= full of energy), mood (1= very sad, 2= neither, 3= very happy) and tension (1= very stressed/ tense, 2= neither, 3= very calm/relaxed).

Standardised Cognitive Tasks

All participants completed the Mini-Addenbrooke's Cognitive Examination (M-ACE, Hsieh et al., 2015) to assess cognitive functioning. It comprises 5 items which assess attention (/4), memory (/7), verbal fluency (/7), visuospatial skills (/5) and memory recall (/7), with a maximum score of 30. There are two recommended cut-offs; 25/30 (a score which is 5 times more likely to have come from a person with dementia than without) and 21/30 (almost certainly a diagnosis of dementia). The M-ACE has been deemed more sensitive than the Mini Mental State Examination (MMSE) and less likely to have ceiling effects (Hsieh et al., 2015). Verbal fluency in the letter -form was also assessed using the letters F, A, S (one minute per letter).

MEAM Task

The task was based on the MEAMs questionnaire developed by Baird and Samson (2014) and was administered orally as a three-point Likert scale for ease, given the participants' cognitive impairment (see Baird et al., 2018 for the amended questionnaire). If participants reported a MEAM they were asked to rate the emotional content of the memory verbally on a 3-point scale (1= negative, 2= neutral, 3= positive).

Music Experience Questionnaire (MusEQ)

The MusEQ (Vanstone, Wolf, Poon & Cuddy, 2016) is a 35-item questionnaire that was specifically designed for people with dementia to assess music listening and engagement across six domains: (1) 'Daily', which addresses the role of music in routine daily life, (2) 'Emotion', which concerns the emotion and mood regulatory aspects of musical experience, (3) 'Perform', which involves music in social contexts such as musical performance and identity, (4) 'Consume', or consumer musical choices, such as buying CD's and attending concerts, (5) 'Response', or responses made in synchrony to music, and (6) 'Prefer', or the extent a person shows preferences or dislikes to certain music styles. The self- rated version was used for the healthy elderly participants and the informant version (close family member, spouse/partner, or a residential care facility staff member who had known the participant for at least 12 months) was used for the participants with AD.

Procedure

The study was approved by the Hunter New England Health and Macquarie University ethics committees. Participants were seen individually and first completed the mood/energy/tension ratings and standardised cognitive tasks, followed by the MEAM task. The 16 songs were individually presented in random order. This was done by pressing “shuffle” on iTunes. Each song was played from the beginning and the participant was asked the questions after approximately 10-15 seconds while the song excerpt continued to play for approximately 30 seconds. Some participants reported a memory within seconds of the song commencing, before they were formally asked the MEAM questions. If this occurred, then the order of the questions was rearranged to start with those related to the memory.

Participants were asked at the initial presentation of the first song whether or not they were able to hear the stimulus. All participants were asked for their consent before filming proceeded and were filmed face on using a small digital camera on a tripod.

Valence and Arousal Ratings of Stimuli

Five independent raters scored the emotional valence and arousal of the 16 songs (3 females, 2 males, mean age 70.2 years). They rated the songs on two separate five-point Likert scales to determine the degree of ‘valence’ (1= very negative to 5= very positive) and ‘arousal’ (1= very low to 5= very high). They songs were presented in random order and each song was played for approximately one minute before the raters made a judgement.

Facial Expressions Analysis

Video recordings were analysed by three independent blind raters (2 females and 1 male, mean age 29 years) to assess the presence of smiles in the AD and healthy elderly participants. All videos of the MEAM task were watched in silence (sound on mute) so that the raters could not identify the verbal content of the segments.

Scoring of the smiles was completed using the Facial Expression Coding System (FACES) (Kring & Sloan, 2007). For each song, raters coded the presence of smiles as detected by a change from a neutral, to a non-neutral (smile) and back to neutral display in participants' expressions. The FACES user guide was given to each rater to ensure consistency between scores. Inter-rater agreement between the three raters for coding the presence of smiles was good, $\kappa = .694$ (95% CI, .60 to .788), $p < .0005$.

Analyses

We conducted two-way mixed ANOVAs to determine the differences between and within the AD and healthy elderly participants ('group') in a) the frequency of smiles during the presence of MEAMs, b) the frequency of smiles during songs from the RB period and c) the timing of smiles and MEAMs. To perform analyses on the frequency of smiles, we created scores of the 'proportion of smiles'. This was computed by dividing the frequency of songs with a smile over the total number of songs from the variable being examined (e.g., songs evoking MEAMs or from the RB period). For example, when looking at the proportion of smiles during MEAMs, if the individual had 8 MEAMs, and smiled during 6 of them, then the individual's proportion of smiles during MEAMs was 75%. The level of significance was set at $p= 0.05$ for all tests. Whilst assessing the frequency of smile data we found that case 3 in the AD group was an outlier by more than 3 standard deviations. After removing this participant there were no other outliers. Therefore, this participant was removed and the analysis was conducted on 8 participants with AD and 10 healthy elderly participants.

Results

Demographic associations

Table 1 displays the demographic characteristics of the participants. As expected, the AD participants had lower scores on all cognitive tasks compared with healthy elderly participants [M-ACE, $t(16)=-4.82$, $p=.002$, and FAS, $t(15)=-3.74$, $p= .003$]. There were no differences between the two groups in age ($p > .50$), or music engagement (MusEQ, $p> .30$ for all subscales). Note that the healthy elderly and AD participants scored below average on the ‘prefer’ scale and AD participants scored below average on the ‘consume’ scale in the MusEQ.

There was no significant association between frequency of smiles and age, gender, cognition (as measured by the M-ACE and FAS) and MusEQ scores in the healthy elderly participants ($p >.10$) or AD participants ($p >.05$). There was a negative association between the ‘consume’ subscale on the MusEQ and the proportion of smiles in the AD participants, $r= -.842$, $p= .017$.

Table 1. Demographic information of the AD and healthy elderly participants. Data presented as mean (standard deviation).

	AD (N=9)	**Healthy elderly (N=10)**
Gender (M/F)	4/5	6/4
Age (years)	77.9 (13.5)	76.0 (9.3)
M-ACE	17.4 (6.3)	29 (0.8)*
FAS	22 (12.3)	42 (7.3)*
MusEQ (mean percentile)		
Total score	40	55-60
Sub-scores		
Daily	40-45	40-45
Emotion	40-45	55-60
Perform	50-55	40-45
Consume	25-30	45-50
Respond	70-75	60-65
Prefer	35-40	30-35

* $p < 0.005$

M-ACE= The Mini-Addenbrooke's Cognitive Examination

FAS= Verbal fluency task (Letters F, A and S)

MusEQ= Music Experience Questionnaire (Vanstone et al., 2016; rated by significant other for AD group)

Association between smiles and subjective ratings of energy, mood and tension

There were no significant differences between the healthy elderly and AD participants in their subjective ratings of energy, mood and tension. The healthy elderly participants reported mean ratings of 2.14 (SD=0.38) for energy, 2.43 (SD=0.53) for mood and 1.57 (SD=0.79) for tension, out of a three-point scale. Similarly, the AD participants scored ratings of 2.12 (SD=0.83) for energy, 2.62 (SD=0.74) for mood and 1.50 (SD=0.53) for tension.

We examined whether subjective ratings of energy, mood and tension had any relationship with the frequency of smiles. There was no significant association between the proportion of smiles and subjective ratings of energy, mood and tension prior to the task in the healthy elderly and AD participants ($p = .20$).

Association between smiles and the valence and arousal of songs

We examined the relationship between the valence/arousal of song ratings and the proportion of smiles that occurred when listening to the song excerpt. There was a significant positive correlation between the song valence ratings and the proportion of smiles in AD participants ($r= .513$, $p =.042$). Songs that were more positively valenced produced a higher proportion of smiles. This relationship was not observed in the healthy elderly participants. There was no association between the arousal ratings of songs and smiles in the AD ($p = .54$) or healthy elderly participants ($p = .40$).

Frequency of smiles during MEAMs

There was no significant difference between AD and healthy elderly participants in the overall frequency of smiles during MEAMs task (p= .654). This was consistent with our expectations of no difference between groups (H1).

To determine whether smiles occurred more frequently when a participant reported a MEAM (H2), we compared the proportion of smiles that occurred during the presence of absence of a reported MEAM. We found a significant main effect, $F(1)=31.97$, $p< .0005$, $\eta^2= 0.666$. Both healthy elderly and AD participants produced a significantly higher proportion of smiles when they reported a MEAM (66.29%, SD=28.92) compared with no reported MEAM (25.55%, SD=16.25, see Figure 1). Pairwise comparisons showed that in the AD participants smiles occurred in 72.41% (SD=27.91) of MEAMs, compared to 20.31% (SD=19.19) when there was no MEAM reported (p= .004). Similarly, in the healthy elderly participants, smiles occurred in 61.40% (SD=30.23) of reported MEAMs, compared to 29.74% (SD=12.99) in the absence of a MEAM (p= .005).

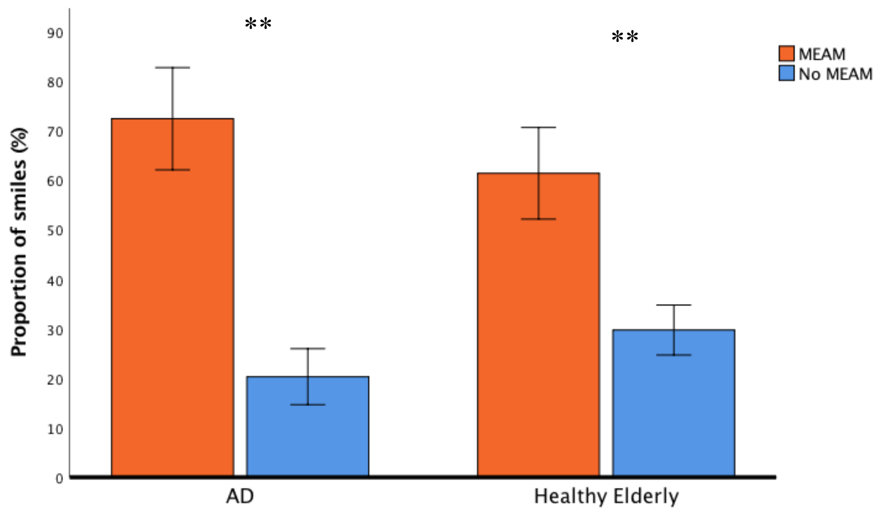

Figure 1. Proportion of smiles during a reported MEAM or no reported MEAM for AD (Alzheimer's dementia) and healthy elderly participants. Error bars +/- 1 SE. * p<0.05, ** p<0.005.

Smiles during songs from the reminiscence bump (RB) period

Overall smile frequency

An ANOVA was conducted to determine the frequency of smiles in response to songs from the RB period compared with songs from later decades (H3a). There was a trend toward an interaction between group and song-type, $F(1)=4.023$, $p= .062$. Subsequent post hoc comparisons showed that in the AD group there was a significantly higher proportion of smiles when listening to songs from the RB compared to songs from other decades ($p=.002$), with means of 69.37% (SD=26.11) and 27.16% (SD=17.00) respectively (Figure 2). In contrast, there was no significant difference between the proportion of smiles produced when listening to songs from the RB period (50.00%, SD=31.09) compared to songs from other decades (37.80%, SD=19.46) in the healthy elderly participants ($p=.312$).

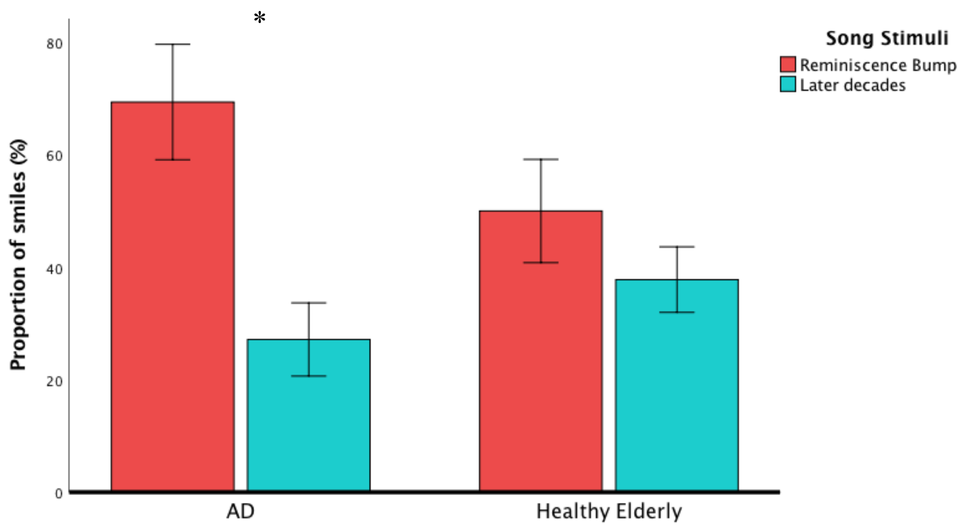

Figure 2. Proportion of smiles triggered by songs from the reminiscence bump period (10-30 years) compared with later decades for AD (Alzheimer's dementia) and healthy elderly participants. Error bars +/- 1 SE. * $p<0.05$.

Smile frequency during MEAMs

An ANOVA was conducted to explore the frequency of smiles when a MEAM was triggered, in response to songs from the RB period compared with songs from the later decades (H3b). There was a trend towards an interaction between group and song-type, F(1)=3.69, *p*= .073. Post hoc comparisons found that in the AD participants, there was a trend (*p*=0.056) for a higher proportion of smiles during MEAMs that were triggered by songs from the RB period compared to songs from other decades [87.50% (SD=12.20) and 58.12% (SD=12.71) respectively, see Figure 3]. There was no significant difference between the proportion of smiles produced when a MEAM was triggered by songs from the RB (60.83%, SD=10.91) compared to songs from other decades (66.24%, SD=11.37) in the healthy elderly participants *(p*=.675).

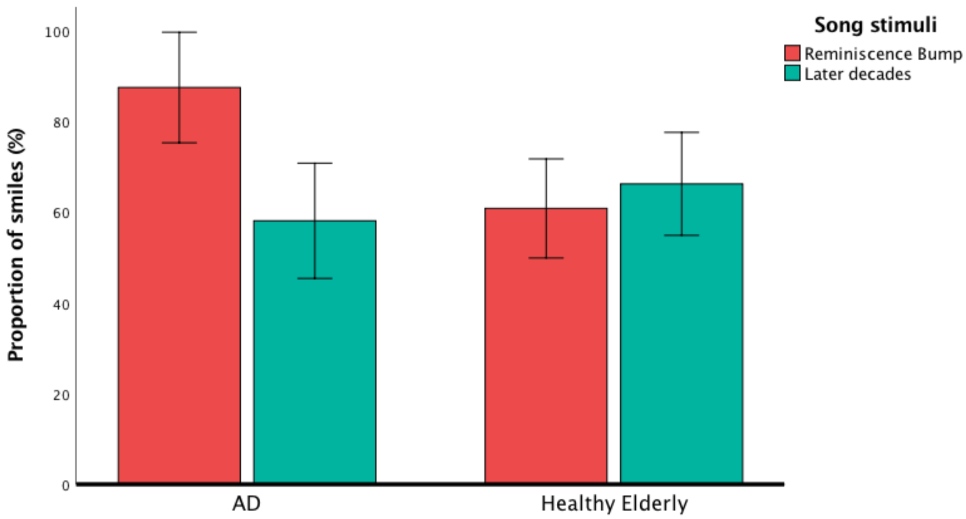

Figure 3. Proportion of smiles during MEAMs triggered by songs from the reminiscence bump period (10-30 years) or MEAMs triggered by songs from later decades (31+) for AD (Alzheimer's dementia) and healthy elderly participants. Error bars +/- 1 SE.

Timing of smiles and MEAMs

To determine the timing of smiles and reported MEAMs (H4), we calculated the proportion of smiles that were triggered before the onset of reporting a memory (‘before’ a memory) and the proportion of smiles that were triggered after the memory was reported (‘after’ a memory). For example, if the participant had a total of 10 songs with smiles and 5 smiles occurred before a memory and 3 smiles occurred after a memory, then they would have had a proportion of 50% smiles before and 30% after (with the remaining 20% of smiles not occurring during a reported memory). There was a trend towards a significant main effect of the timing of smiles, $F(16)=4.06$, $p= .061$. Pairwise comparisons revealed that the healthy elderly participants had a significantly higher proportion of smiles before the onset of a memory (37.67%, SD=17.27) compared with after (14.42%, SD=18.50) ($p= .043$). The AD participants also showed a higher proportion of smiles before the reported MEAMs (43.62%, SD=34.88) compared with after (24.91%, SD=25.25), but this did not reach statistical significance ($p= .377$, see Figure 4).

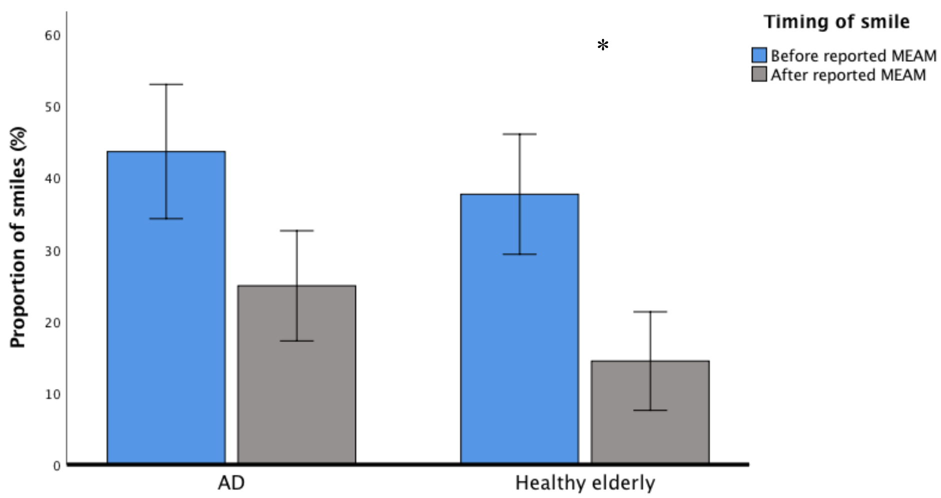

Figure 4. Proportion of smiles before or after the onset of a reported MEAM in AD (Alzheimer’s dementia) and healthy elderly participants. Error bars +/- 1 SE. * $p<0.05$.

Smiles and the subjective experience of MEAMs

To investigate the relationship between the objective positive emotional responses (smiles) and a participant's subjectively rated emotional response during a MEAM (H5), we calculated the proportion of smiles that occurred for each subjective emotional rating category of the MEAM (from 1, negative, to 3, positive). There was a significant main effect for rating type, F (2)=18.21, $p< .0005$, $\eta^2= 0.757$. Pairwise comparisons showed that that the healthy elderly participants had a significantly higher proportion of smiles during memories that were rated as positive, 60.07%, (SD=33.59) compared with those rated as negative 10.00%, (SD=31.62) ($p< .0005$). They also demonstrated a trend towards a difference in the proportion of smiles between positively rated memories and those rated as neutral 23.33%, (SD=41.72), though this did not reach statistical significance ($p= .067$). The AD participants also had a significantly higher proportion of smiles during memories that were rated as positive, 73.44% (SD=27.26) compared to those that were rated as neutral 12.50%, (SD=35.35) ($p= .003$, see Figure 5).

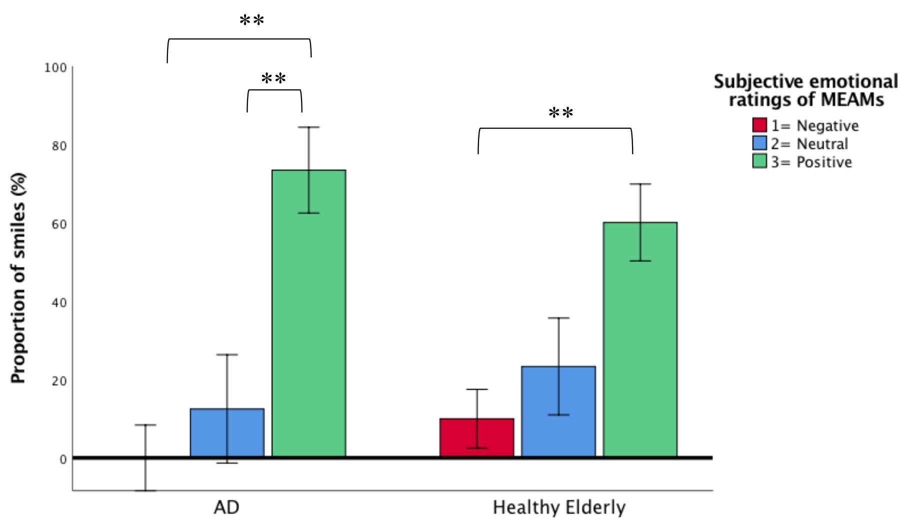

Figure 5. Proportion of smiles during MEAMs and their corresponding subjective emotional ratings of memories in AD (Alzheimer's dementia) and healthy elderly participants'. Error bars +/- 1 SE. ** p<0.005.

Discussion

This study is the first to objectively examine positive facial expressions, specifically smiles, during MEAMs in people with AD. We measured the frequency of smiles whilst participants listened to famous songs across eight decades and recalled autobiographical memories. Our main finding was that both AD and healthy elderly participants produced a greater proportion of smiles when reporting MEAMs, compared to when no MEAMs were reported. Furthermore, we observed that smiles more commonly preceded the onset of the reporting of MEAMs in healthy elderly participants, and there was a trend for this to occur in AD participants.

MEAMs and enhanced positive emotional response

Our results provide behavioural evidence in support of the emotional nature of MEAMs, through the objective assessment of the presence of smiles. Our findings of a higher proportion of smiles during MEAMs than in the absence of MEAMs, supports Juslin and Västfjäll's (2008) prediction that "we would expect episodic memories associated with music to be particularly emotionally vivid" (p. 567). This finding offers further evidence for the association between emotion, music and autobiographical memory in people with AD.

Previous studies have documented the emotional experience of MEAMs through the analysis of self-ratings and verbal content (El Haj, Fasotti & Allain, 2012; El Haj, Postal & Allain, 2012). These studies found that MEAMs were self-rated as more positive by both healthy elderly and AD participants (El Haj, Fasotti & Allain, 2012), and that MEAMs in response to familiar music contained more positive words compared to researcher chosen music or silence (El Haj, Postal & Allain, 2012). In addition, autobiographical memories were more likely to be evoked when listening to a song that triggers an individual emotionally (Schulkind, 1999). Our observation of a greater proportion of smiles during MEAMs than in the absence of MEAMs confirms the emotional nature of MEAMs by providing behavioural evidence to support these previous findings.

Furthermore, the result also extends our understanding of the positivity effect; that autobiographical memories produced by healthy older adults and people with AD are self-rated as particularly positive (Cuddy et al., 2017). Our finding that MEAMs were associated with a higher proportion of smiles demonstrates the overall positive nature of the autobiographical memories triggered. It should be acknowledged that certain qualities of the music itself may reinforce these positive emotional responses to MEAMs. That is, combining extrinsic (autobiographical memories) and intrinsic (music) sources of emotion may optimally elicit positive responses. Additionally, we found that the objective measure of smiles corresponded to the participants' subjective feeling of the positive nature of the memory that was reported. This 'matching' between the participants' subjective rating and facial expressions of emotion confirms our knowledge of the positivity effect by demonstrating that memories elicited by music are not merely self-rated as positive, but are also experienced as positive in people with AD.

Importantly, we found a similar emotional response during MEAMs in people with AD and healthy elderly people. This is in keeping with previous observations during MEAM tasks where positive emotional responses, such as smiling, laughing and nodding, were measured and similarities were noted between AD and healthy elderly groups (Belyea et al., 2016). This finding has important implications as it demonstrates that affective responses to music endure, which is in contrast to the emotional indifference when engaging with other mediums, such as pleasant pictures (Drago et al., 2010).

Interestingly, differences between AD and healthy elderly participants were observed relating to the pre-rated valence of songs and their influence on emotional responses. In AD participants only, positively valenced songs were more likely to trigger smiles. For both AD and healthy elderly participants, the level of song arousal made no difference to emotional responses. This is in keeping with a recent study by Garrido, Stevens, Chang, Dunne and Perz (2018b) in which the mode of the music influenced the mood of people with dementia. In their study, participants who listened to songs that were in minor keys exhibited more facial expressions indicative of sadness, as opposed to participants who listened to major keys (more positively valenced) who displayed fewer. This demonstrates the importance of the song choice for inducing a positive emotional experience in AD.

Our findings of the preservation of positive emotional responses during MEAMs in AD could be explained by the role of the medial prefrontal cortex (MPFC) in associating music and memory (Janata, 2009). The MPFC is a neural substrate that plays a role in MEAM retrieval in healthy adults, particularly for highly emotional memories triggered by familiar songs (Janata, 2009; Ford et al., 2016; Ford, Addis & Giovanello, 2011). In AD, the MPFC is relatively preserved compared to other brain areas (Thompson et al., 2003). Therefore, it is not surprising that we observed intact emotional processes during MEAMs in AD participants.

Timing of emotion and autobiographical memory

We explored the relationship between music, emotion and autobiographical memory by examining the timing of smiles and MEAMs, to see whether smiles occurred before or after the reported MEAM. Juslin and Västfjäll (2008) posited that music evokes memories about one's life and emotions are induced via these memories. However, our findings showed that smiles more commonly preceded the onset of the reporting of MEAMs, suggesting that the emotion felt from the music may be the catalyst for the autobiographical memory. Although this was statistically significant in healthy elderly participants, there was only a trend for this to occur in AD. These results suggest that one of the predominant mechanisms previously identified as triggering MEAMs is emotion (Bower, 1981; El Haj, Fasotti & Allain, 2012; El Haj, Postal & Allain, 2012), whereby feeling an emotion may prompt a memory associated with that specific emotion (Bower, 1981).

Emotion, memory and personally relevant songs

We predicted that there would be a greater positive emotional response during songs that were more personally relevant (from the RB period) compared to those that were less personally relevant (from later decades). Our data showed a difference between AD and healthy elderly participants in smiles elicited by songs from the RB period (when the individual was aged 10-30 years). Firstly, songs from the RB period triggered more smiles than songs from later decades in individuals with AD, but not in the healthy elderly. In addition, AD participants also produced more smiles during MEAMs triggered by songs from the RB period compared with MEAMs triggered by songs from the later decades. In other words, songs from the RB were particularly potent at eliciting smiles both unaccompanied and accompanied by MEAMs in the AD participants. Our results provide objective evidence that songs from a personally significant time period elicit a heightened positive emotional response. Additionally, it also complements findings that songs that are more personally relevant produce more MEAMs with higher emotional content in people with AD, compared with songs that pertain no personal relevance (El Haj, Fasotti & Allain, 2012; El Haj, Postal & Allain, 2012). Nevertheless, the fact that we did not show this in our healthy elderly participants is not consistent with Schulkind's (1999) finding that older adults had stronger emotional responses (self-rated on a Likert scale) to music from their younger years.

These finding may reflect the temporal gradient for autobiographical memory in people with AD; whereby remote events, such as those from childhood and early adulthood, are recalled better than recent events (Kopelman, 1989; Addis & Tippett, 2004). These remote memories have been shown to be important in the maintenance of self-identity in people with AD, as they contribute to more concrete quality of identity (e.g.,Addis & Tippett, 2004; Fitzgerald, 1988). Music plays an important role in establishing our identity during our younger years, and we often listen to music throughout our lives to reinforce our sense of self. When this same music is heard later in life, the associated memories can be triggered, including the dominant emotions and sense of self associated with that period of life. Thus, songs from the RB period, due to their emotionally laden nature, may be particularly crucial for the sense of identity, especially for people with AD (Baird & Thompson, 2018).

Future directions and limitations

The participants' own subjective judgements of the positivity of their MEAMs were matched in the results from our observational technique of examining facial expressions. This is similar to findings of El Haj et al. (2016) and Gandolphe et al. (2018) who used computerised facial recognition software, demonstrating the validity of the

FACES manual (Kring & Sloan, 2007) to detect smiles. Future studies should investigate a wider range of emotions to truly determine the nuance of the affective experience of emotion during MEAMs. In the present study there was no measure of non-positive responses. This would be an important measure for future studies to consider, particularly given that the type and severity of dementia can contribute to a decrease in pleasurable responses to the music. (Garrido et al., 2017; Garrido, Stevens, Chang, Dunne & Perz, 2018a,b).

There are a number of challenges of the participant population and experimental design, which warrant close consideration in interpreting the findings. The sequence of events in the procedure of the study may disturb our finding of emotion occurring before a MEAM. Given the nature of the task, our participants were prompted to retrieve a memory. Perhaps the participants were waiting for the experimenter to prompt them and therefore did not discuss the memory as it occurred. Nevertheless, memories triggered by songs were often spontaneously discussed before the experimenter asked, suggesting that it was indeed the music inducing the emotion and subsequent MEAM. The relationship between the timing of emotions and memories warrants further investigation to determine the mechanism of action.

In addition, our results are based on a small sample size of eight participants with AD and therefore, should be seen as preliminary. In addition, the fact that our study used popular songs that were listed as “number one” could have introduced a bias for more positive and high arousal songs.

Concluding remarks

This is the first study to objectively measure positive emotional responses (smiles) during MEAMs in people with AD. This is particularly important as it provides a way of measuring emotion in people with dementia, without placing cognitive demands on them. Our findings showed that positive emotional responses occur more frequently during MEAMs in people with AD, in particular for songs from the reminiscence bump, and confirm the positive nature of MEAMs. These results emphasise the importance of the emotional and personal capacities of music in autobiographical memory retrieval in people with AD. We can conclude that certain music has the ability to 'awaken' people with AD emotionally, stressing the importance of using songs that are relevant to personally significant times in one's life (e.g.,from the RB) and songs that are positively valenced to achieve this particular affective outcome. This has clinical significance when choosing music for therapeutic music interventions for people with AD.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

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CHAPTER 4

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CHAPTER 4

Chapter 5:

General Discussion

This thesis explores the use of music as a treatment tool for people with dementia. I argue that music combines powerful attributes and capacities that make it an effective treatment for neurological disorders, specifically dementia. The *Therapeutic Music Capacities Model* (TMCM) was proposed as a framework that identifies seven attributes of music affording therapeutic benefits for people with dementia, and their mechanisms of operation. I evaluated the application of the TMCM as a resource for (a) developing a music-based program that capitalises on all seven capacities of music for people with dementia (the *Music, Mind and Movement* program) and (b) drawing upon and emphasising particular capacities in order to target specific functions in people with dementia, thereby optimising treatment to address the individual needs of each patient.

Along with increased longevity in society there is a corresponding increase in the prevalence of dementia. Given this shift in the age of our population, interventions that are minimally invasive, inexpensive and cause limited adverse reactions, are needed to manage a variety of age-related cognitive, emotional and behavioural challenges. Music's versatile therapeutic nature has stimulated increasing research into how it confers benefits on neurological disorders, particularly in people with dementia (for reviews see Baird & Samson, 2015; Särkämö, 2018). Researchers and clinicians are aware of the need to understand the active ingredients and mechanisms that underlie music-based interventions. Thus, a central contribution of this thesis is the TMCM, which outlines seven therapeutic capacities of music; that it is engaging, emotional, physical, personal, social, persuasive and permits synchronisation. I have demonstrated that this model can explain the therapeutic value of music for neurological disorders, primarily focusing on dementia. I have also established that the TMCM can be used to devise new music-based therapeutic programs that capitalise on all seven capacities. Finally, I have shown that the model allows for specific capacities of music to be extracted and studied in detail to further understand how they can contribute to optimal cognitive functioning in people with dementia.

The aim of this final chapter is to review the theoretical and experimental studies completed for this thesis and outline their primary significance for research and practice. A modified version of the *TMCM,* depicted in Figure 1, is then presented based on the evidence gathered from my experimental findings, along with recent theory on how the brain responds to age-related decline and environmental input. This updated model incorporates the concept of *neural scaffolding* as a potential mechanism involved in the effects of music-based treatments for improving cognitive function in people with dementia, as we saw from the MMM program study (Chapter 3). It also provides evidence for the capacity of the emotional and personal nature of music to improve autobiographical memory, as observed in the MEAM and emotion study (Chapter 4).

Summary of chapters

At the core of this thesis is a comprehensive model of the therapeutic effects of music on people with neurological disorders: the TMCM. The aim of Chapters 1 and 2 was to provide a theoretical grounding for this model, and to motivate the empirical work completed for the thesis. Chapter 1 provided a comprehensive review of current research on music's capability of improving cognitive, psychosocial, behavioural and motor functions in people with neurological disorders such as dementia, stroke, Parkinson's disease and Autism Spectrum Disorder. It critically examined and extended a proposal made by Thompson and Schlaug (2015) that the therapeutic value of music can be largely traced to seven therapeutic attributes of music: that music is engaging, emotional, physical, personal, social, persuasive and permits synchronisation. The TMCM links these seven capacities of music to mechanisms of recovery. Chapter 1 outlined how and why these capacities have reliable benefits for the aforementioned neurological impairments, whether they are employed separately or in combination. Chapter 2 extended this comprehensive review by focusing on the TMCM and discussing how this framework can be applied to people with dementia. I concluded that the TMCM could effectively account for the profound value of music in maintaining well-being and improving cognitive function in people with dementia.

In Chapter 3, the translational potential of TMCM was explored in the development and assessment of the *Music Mind and Movement* (MMM) program for people with dementia living in a residential aged care facility. Based on a sample of 20 individuals with mild to moderate dementia, we measured cognition, mood, identity, and fine motor skills before and after the MMM intervention compared with a period of standard care. The aim of this study was to determine whether incorporating all seven attributes of music in one single treatment would further enhance the effect of music's efficacy as a treatment. Individuals who participated in the MMM program had an improvement in cognition, specifically in areas of attention and verbal fluency, whilst individuals who received standard care demonstrated a decline in cognition. These preliminary findings suggest that the MMM program can improve cognition, namely verbal fluency and attention, for people with dementia. We then proposed that the neural mechanism through which the seven capacities of music may improve cognition in people with dementia is through the enhancement of the process of neural scaffolding. The

Scaffolding Theory of Aging and Cognition (STAC, Park & Reuter-Lorenz, 2009) describes a set of neurological processes occurring during the course of ageing that act to reinforce declining structures. By engaging in an enriched environment, like the MMM program, individuals can reinforce processes of neural scaffolding, resulting in additional or renewed neural circuitry.

The neuropathology of dementia interrupts or hampers this scaffolding process, potentially leading to its collapse. Music and its broad network of capacities can engage brain regions that are typically involved in neural scaffolding, such as frontal areas that are typically relatively preserved in people with the most common type of dementia, Alzheimer's Dementia (AD). By including all seven capacities of music, the MMM program places participants in a particularly enriched, novel and challenging environment. This state of deep engagement may prime or 'scaffold' other (non-musical) cognitive functions. Thus, by maximising cognitive stimulation with the seven capacities of music in a process of creative engagement, we propose that music can support the natural process of neural scaffolding.

As part of the MMM program I also developed the MMM Manual (Appendix A), which is a step-by-step guide of how to run the MMM program for carers (both family and professional) and health professionals. It details the types of music activities to include to maximise the benefits of music-based treatments. As stated in the manual, the activities and equipment can be modified, omitted or added to suit each participant's psychosocial and cognitive-motor circumstances and needs. The purpose of the manual is to allow sufficient detail for staff at other aged care facilities to run the MMM program.

This thesis also argues that the TMCM allows for the systematic testing of a single capacity of music, or numerous capacities, to determine their direct links and benefits for certain functions in neurological populations. Hence, in Chapter 4, we chose to examine the personal and emotional attributes of music and observe their effects on music evoked autobiographical memories (MEAMs) in people with AD. We observed the relationship between MEAMs and smiles. This study was the first to measure positive facial expressions during MEAMs in people with AD. Measuring smiles as a surrogate marker of emotion in this population has valuable consequences given the susceptibility of self-report measures to problems of demand characteristics that present with cognitive impairment. Measuring facial expressions through smiles allows a person with dementia to communicate the emotional content of memories, compensating for their impaired cognition. There was no significant difference between AD and healthy elderly in the frequency of smiles during the MEAM task, demonstrating that positive emotional responses, in the form of smiles, remain intact in people with AD during MEAMs. Both AD and healthy elderly individuals produced a significantly higher proportion of smiles in the presence of a reported MEAM. In the AD participants only, there was a higher proportion of smiles during songs from the reminiscence bump period (aged 10-30 years) compared to songs from later decades (31+ years) as well as a higher proportion of smiles during those MEAMs triggered by songs from the reminiscence bump period. Interestingly, we also found the emotional response (smiles) tended to precede the reported MEAM. These results confirm the positive nature of MEAMs and emphasise the significance of the emotional and personal capacities of music for autobiographical memory retrieval in people with AD. Through this study we demonstrate that the TMCM can be used as a framework for isolating certain attributes of music to identify their individual contributions to improve autobiographical memory function in people with AD.

CHAPTER 5

Revised Therapeutic Music Capacities Model (TMCM)

The empirical results of Chapter 3 and 4 provide evidence to support some of the pathways by which the seven capacities of music may lead to positive outcomes in people with dementia. In particular, I have introduced the mechanism of neural scaffolding to account for the benefits in cognition by engaging all seven capacities in a music-based treatment, such as the MMM program. I have also defined the links between the *emotional* and *personal* capacities of music and their specific benefits for the cognitive outcome of autobiographical memory. Thus, a revised version of the TMCM is presented. Figure 1 depicts this revised model based on evidence gathered through the experimental chapters of this thesis (Chapter 3 and 4). The figure illustrates plausible pathways deduced from the experimental data described in Chapter 3 (examination of MMM program, shown in red), and Chapter 4 (MEAMs and emotion study, shown in blue). The pathways coloured in green represent hypothesised links between the *emotional, personal* and *social* capacities of music to psychosocial and behavioural benefits, which are based on the results from my empirical studies and from insights gained from my review of the literature (Chapter 1 and 2).

Using the revised TMCM as a framework, the MMM program study (Chapter 3) adopted a 'group' scenario consisting of both 'active' (music making) and 'passive' (music listening) activities. The program included activities that incorporated all seven capacities of music. From our understanding of the STAC framework (Reuter-Lorenz & Park, 2014) and interpretation of our results, we posited that the beneficial effects of these seven capacities of music on cognition (verbal fluency and attention) were realised by an interaction between this form of environmental enrichment and natural processes of neural scaffolding, as reflected in the modified TMCM model.

GENERAL DISCUSSION

The MEAMs and emotion study (Chapter 4), which took place in an 'individual' and 'passive' (music listening) context, focused on the specific effects of the *personal* and *emotional* capacities of music. Given the increase in positive emotional response (smiles) during MEAMs and songs from the reminiscence bump period, we can conclude the importance of the personal nature of music in triggering autobiographical memories. In addition, given the comparable frequency of smiles between people with AD and healthy elderly during MEAMs we can conclude that the stimulation of emotion is a valuable feature of music for eliciting autobiographical memory. In further support of this conclusion, when we measured the timing of emotions during MEAMs, the results pointed towards the elicitation of emotion (smiles) first, followed by the reporting of a MEAM, which may corroborate the importance of the emotional nature of music in producing autobiographical memories. These empirical findings have consolidated the link between the *emotional* and *personal* capacities of music and their value for autobiographical memory.

Following on from my two empirical studies, I hypothesised how the *emotional, personal* and *social* capacities of music connect to psychosocial and behavioural outcomes based upon the results from my empirical findings (Chapter 3 and 4) and established findings in the literature to date (summarised in Chapter 1 and 2). These links are illustrated by the green pathways in Figure 1. Firstly, I noted that the aspects of the MMM program that were most valued by the participants were social interaction and the personal and emotional nature of the program. Previous research suggests that singing in groups and listening to personalised music can reduce levels of agitation and isolation in people with dementia (Lesta & Petocz, 2006; Harris & Caporella, 2014; Gerdner & Swanson, 1993; Gerdner, 2000; Sung, Chang and Lee, 2010). The production of MEAMs in people with dementia can often lead to an emotional response and a positive state of mind (Cuddy, Sikka, Silveira, Bai, & Vanstone, 2017). Further, listening to pre-recorded and live music and making music all have the capacity to reduce apathy, a common symptom in people with dementia (Holmes, Knights, Dean, Hodkinson & Hopkins, 2006; Massaia et al., 2018; Tang et al., 2018). Thus, combining my results from the MMM program with these existing findings in the literature, I hypothesised that the *social*, *personal* and *emotional* capacities of music may also assist psychosocial functions (mood) and behavioural functions (isolation and agitation), as suggested in the modified TMCM (Figure 1). Although the results from the MMM program did not yield any group differences in mood (specifically symptoms of depression), this may be due to the lack of broader mood measurement, such as measuring anxiety as well (as discussed in Chapter 3). Secondly, in the MEAMs and emotion study I observed the importance of the *personal* and *emotional* capacity of music in triggering MEAMs. Previous findings suggest that the decline in autobiographical memory function in people with AD, may correspond with a loss of identity, impacting negatively on well-being (Jetten, Haslam, Pugliese, Tonks & Haslam, 2010). Thus, we can hypothesise that the *personal* and *emotional* capacity of music to trigger autobiographical memories may facilitate the maintenance of self-identity in people with AD, as illustrated in the revised TMCM.

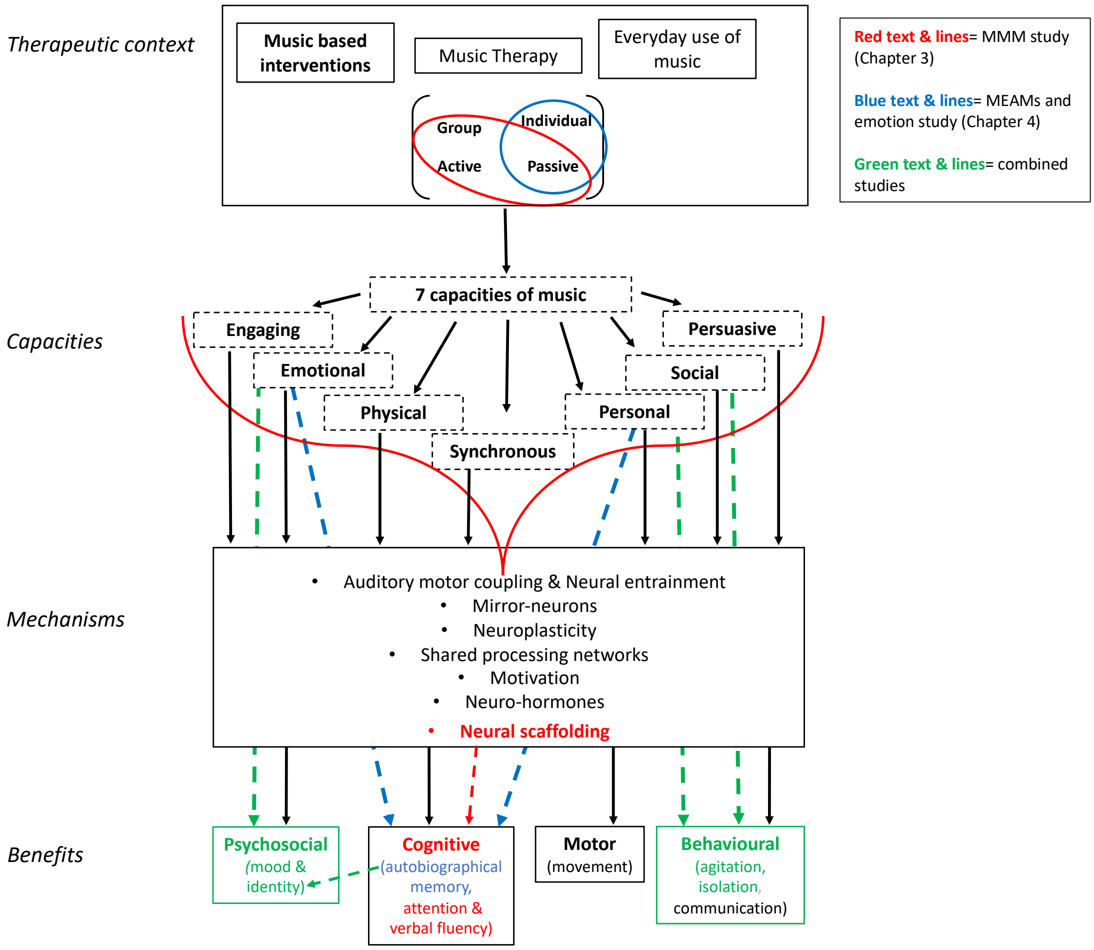

Figure 1. A modified version of the Therapeutic Music Capacities Model. The different colours represent the relative contributions of the results from the two experiments. The red colour represents findings from the Music, Mind and Movement program (Chapter 3) and the blue colour represents findings from the Music Evoked Autobiographical Memory and emotion study (Chapter 4). The green colour represents hypothesised connections based on empirical findings from Chapters 3 and 4 and prior knowledge from Chapters 1 and 2.

Impact of findings on dementia care

The life-changing effect of dementia not only applies to the person diagnosed, but extends to families, carers and the wider community. The development of the TMCM and MMM program has several implications for both the individual and the wider management of people with dementia.

CHAPTER 5

The formal assessment of the efficacy of the MMM program, outlined in Chapter 3, highlights its potential to improve cognition, particularly verbal fluency and attention, in people with mild to moderate dementia in an aged care residential facility. Such improvements have the potential to impact on the daily functioning of these individuals and have positive ramifications for carers. For example, improved attention and verbal fluency could facilitate communication, enabling social engagement, which in turn improves well-being and quality of life. It may also have benefits for the reduction of disorientation, which is often a cause of distress in people with dementia. Furthermore, participating in the MMM program increases social bonds, reducing loneliness. The last session of the MMM program, in which younger musicians from the Conservatorium of Music visit the residential aged care facility and play music, is another potential means of encouraging social inclusion and participation within the wider community. In particular it may help to reduce the stigma associated with dementia. Additionally, listening to personally relevant music which subsequently stimulates autobiographical memories and triggers positive emotional responses (as observed in the MEAMs study), could improve mood and reduce agitation. These improvements in the individual's psychosocial and cognitive domains is likely to have positive consequences for carers by reducing the burden that is placed on them by individual demands.

The benefits of the MMM program cascade outwards from the individuals involved out to their wider support network. Listening and responding to music is a meaningful way to engage with one another, despite a dementia diagnosis. The MMM program may provide a structured way to facilitate engagement and communication, reducing care-giver burden. In particular, the MMM manual allows for the program to be administered by carers, family members, friends or health care professionals. The activities in the MMM program lend themselves to being employed in a home setting as the activities are explained in detail in the manual and they do not require the use of expensive instruments. There is value in keeping people with dementia in their home and community for the maintenance of their sense of independence and the continuation of familiarity with their environment and loved ones. The improvement in attention and verbal fluency observed after participating in the MMM program may translate to better communication between the person with dementia and their primary carer as well as keeping them oriented in the home setting. In the MMM program study, we also observed a negative relationship between time in residency and cognitive improvement, whereby individuals who had been residents at the aged care facility the longest had the least improvement in cognition after the program. This outcome stresses the importance of early intervention, potentially by using the MMM program in the home environment, thus delaying admission to an aged care facility

The MMM manual provides detailed instructions in order to deliver effectively the program in remote, rural and culturally diverse communities. It is projected that over the next 40 years the greatest rise in dementia will be seen in the Northern Territory, with the risk of Aboriginal and Torres Strait Islanders being 3-5 times higher than the non-indigenous population. In addition, people from linguistically diverse backgrounds, classified as speaking a language other than English at home, make up 20% of people with dementia (Brown, Hansnata & La, 2017). Music can offer a way for individuals to engage with one another despite language barriers. Individuals can make music or move to music with one another despite lacking a common language. The MMM program offers a variety of means for individuals to engage in the program in their own way. For example, the songs chosen are encouraged to be those that are personally relevant to the individuals, regardless of cultural background or native language. Participants are invited to engage with the music by playing an instrument, singing, humming, moving or just listening, all of which do not require language. In this way, the MMM program may be a useful tool for people with dementia from culturally diverse backgrounds.

Issues that arise in the face of dementia spread beyond the individual and community level to the wider nation. At present, the projected cost of dementia care over the next 40 years in Australia is more than $36 billion (Brown et al., 2017). Preventative programs which capitalise on ‘protective factors’ against dementia present the opportunity to reduce its incidence each year. Engaging in music and music- based activities on a regular basis have known protective mechanisms against cognitive decline (as discussed in Chapter 1 and 2). The TMCM has translational implications for devising and implementing other music-based programs to prevent dementia. Given there is no cure for dementia as yet, there is the need to focus on reducing the risk of dementia and managing it as best as possible once it occurs.

Whilst music is deemed a particularly effective tool in the management of behavioural symptomology associated with dementia, it is important to acknowledge that other pleasant activities may also confer similar benefits, particularly for the emotional wellbeing and reduction in severity of behavioural disorders (e.g., cooking, see Samson, Clément, Narme, Schiaratura & Ehrlé, 2015). This is not surprising given that other activities share some of the same therapeutic capacities as music, such as their social, personal and emotional nature. This thesis argues that the primary reason why music may be regarded so highly as an effective therapeutic medium is because it combines multiple therapeutic capacities in an enjoyable activity that is ubiquitous and easy to administer in any context. This is unlike activities such as cooking or gardening, which are less practical as a therapeutic intervention, particularly in dementia. Moreover, the capacities are relevant to health and wellbeing at almost any stage of the dementia (Chapter 2). Thus, music is unique in its ability to span the varying symptomology and severity of dementia.

Concluding remarks

There are more people living today than ever before, and they are living longer. Longevity is a double-edged sword; it permits greater experience, fulfilment, and contribution to society, but also presents challenges associated with age related decline, such as dementia. Given the significance of these challenges for individuals, families, and society, there is a pressing need to understand how we can preserve or enhance daily functioning for the ageing population. In this thesis, I presented theoretical and empirical arguments that music holds the key to preserving and even enhancing a range of functions including cognition, emotional well-being and autobiographical memory. Music is uniquely powerful because it simultaneously engages multiple psychological, social and motor functions, providing a potent combination therapy that places the brain in an enriched setting. I outlined a novel theoretical model, the TMCM, in order to provide a blueprint for investigating the capacities of music that stimulate positive outcomes in people with dementia. As we learn more about the active ingredients and mechanisms underlying the therapeutic value of music, it should be possible to design programs that address an individual's specific needs, benefitting not only people with a neurological condition such as dementia, but all of us.

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Appendix I:

Ethics Approval

Ethics approval (pages 222-228) removed from Open Access version as they may contain sensitive/confidential content.

Appendix II:

The Music, Mind and Movement program manual

Pages 230-262 of this thesis have been removed as they contain published material.

Appendix III:

Characterisation of music and photo evoked autobiographical memories in people with Alzheimer's Dementia

Pages 264-277 of this thesis have been removed as they contain published material. Please refer to the following citation for details of the article contained in these pages.

Baird, A., Brancatisano, O., Gelding, R., & Thompson, W. F. (2018). Characterization of music and photograph evoked autobiographical memories in people with Alzheimer's disease. *Journal of Alzheimer's Disease*, *66*(2), 693-706.

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