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PHYSIOLOGICAL RESPONSES OF PEOPLE WITH DEMENTIA DURING PSYCHOSOCIAL INTERVENTIONS

Section A: What do physiological responses tell us about the emotional state of people with dementia during psychosocial interventions

Word Count: 7995 (30)

Section B: Singing and music making: Physiological responses of people during early and later stages of dementia

Word Count: 7997 (497)

Overall Word Count: 15,992 (527)

A thesis submitted in partial fulfilment of the requirements of Canterbury Christ Church University for the degree of Doctor of Clinical Psychology

NOVEMBER 2020

SALOMONS INSTITUTE

CANTERBURY CHRIST CHURCH UNIVERSITY

Acknowledgments

I would like to thank my supervisors Professor Paul Camic, Professor Sebastian Crutch, Fergal Jones and the created out of mind team for their support, knowledge and guidance. Thank you to the Wellcome Trust who funded the Created Out of Mind Arts and Dementia project at Wellcome Collection for providing funding for the Empatica E4 video cameras. I am so grateful to the people who took part in the research and their families for allowing their experiences of these interventions to be shared. I would also like to thank the facilitators and musicians of the choral group and the Music for Life team for allowing me to explore their wonderful work.

I would like to thank my family Dad, Lorna, Clair, Gabor and Rianna and my amazingly supportive friends. Special thanks to Sarah for her help with my project. Finally, I would like to thank my partner Joe for his love and support over the past three years.

Summary

Section A is a literature review exploring what physiological responses and psychometric measures tell us about the experience of an individual with dementia during a psychosocial intervention. The review included eighteen peer reviewed studies that included both a psychometric measure of emotional state and physiological responses to evaluate the effect of a psychosocial intervention for people with dementia. The broad range of measures and interventions made it hard to draw firm conclusions, however findings indicate heart rate and heart rate variability were most consistently associated with improvements in mood and behaviour across a broad range of interventions. Salivary assays also showed promise however data collection was a challenge.

Section B consisted of two linked multiple-case studies which measured physiological responses during two music-based interventions; a singing group for people with mild-moderate dementia and an interactive music group for people in the later stages of dementia. Results showed some changes in physiological response related to the intervention and changes in music. Findings indicated that physiological responses may provide valuable information about the experiences of people with dementia, particularly if used in conjunction with other measures. Future research combining video analysis, observations and physiological measures was recommended.

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Section A: Literature review

What do physiological responses tell us about the emotional state of people with dementia during psychosocial interventions

Word count: 7995 (30)

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Abstract

Physiological responses are increasingly being considered to provide information about the benefits of psychosocial interventions for people with dementia. and may be particularly valuable when communication skills have deteriorated. This review aimed to consider what physiological responses tell us about the emotional state of people with dementia during psychosocial activities.

An electronic literature search of four databases was undertaken to identify studies that included both a standardized measure of emotional state and physiological responses as outcome measures of a psychosocial intervention for people with dementia. Reference lists were also hand searched to identify additional relevant papers. Eighteen papers were included in the review.

Results found heart rate and heart rate variability were most consistently associated with an improvement in mood and behaviour across a range of interventions. The findings from salivary assays were more mixed however, indicating they may be a useful indicator of mood, however collecting saliva samples remains a challenge.

Small sample sizes and a broad range of measures and interventions make it difficult to draw firm conclusions, however the findings indicate that physiological measures may provide some useful information about the emotional state of people with dementia, particularly when used in conjunction with other measures or observations.

Keywords: Dementia, Physiological, Wellbeing, Psychosocial, Intervention

Introduction

Dementia

Dementia is an umbrella term used to describe a progressive illness with a range of symptoms including a decline in memory, cognition, behaviour, movement and the ability to perform everyday tasks. Alzheimer's disease is the most common and widely known form of dementia, followed by vascular dementia, frontotemporal lobe dementia and dementia with Lewy bodies. Dementia currently affects 50 million people worldwide, with an estimated 10 million new cases each year (World Health Organisation, 2019). Dementia is widely regarded as one of the major causes of disability among older people (WHO, 2019). Despite extensive research being undertaken, there is still no medical cure for any subtype of dementia, therefore finding ways to help people live well with dementia is imperative and research in this area has consequently gained traction.

People with a dementia (PWD) diagnosis often show changes in psychological symptoms such as low mood, anxiety and increased stress (Koopmans et al., 2009; Kales et al., 2015). Consequences of behavioural and psychological symptoms of dementia (BPSD) include increased distress for the individual and the caregiver (Feast et al., 2016), worsening cognition (Canevelli et al., 2013) and increased costs of care (Balesteri et al., 2000). Research suggests that BPSD may increase over time due to a lowered stress threshold as the dementia progresses. The progressively lowered threshold model (PLTM) was based on observations that behaviours displayed by PWD were in response to specific triggers and that as the dementia progressed, these behaviours tend to occur following lower doses of the same triggers (Smith et al, 2004).

Medication has historically been the primary treatment of neuropsychiatric symptoms in people with dementia and some research has found a reduction in agitation and aggression following prescription of neuroleptic drugs (Kratz, 2017). The effectiveness of medication, however, depends greatly on the individual and there is contrasting evidence to suggest that psychotropic drugs have little impact on mood (Bains et al., 2002) or quality of life (Cooper et al., 2012). There has been a shift away from solely using medication evidenced by Living well with dementia, A National Dementia Strategy (2009) which called for a reduction in medication due to the lack of evidence of its effectiveness and the potential side effects. As concerns about use of medication have grown, the concept of dementia as being entirely a disease of the brain has also lost support and there has been an increasing focus on 'person centered care' (Kitwood, 1998). Kitwood emphasised the importance of taking a person's environment and interactions into consideration as well as building care around the individual's needs in order to maintain their 'personhood'. He proposed a shift from the idea of 'managing' neuropsychiatric symptoms to considering them an indication of a need to engage the individual in meaningful activities. More recently, relational models have emphasised the role relationships play in wellbeing. The "senses framework" proposed by Nolan et al., (2004) highlights the importance of all involved parties experiencing a sense of security, belonging, continuity, purpose, achievement and significance.

Psychosocial interventions for people with dementia

Benefits of psychosocial interventions for mood, cognitive functioning, quality of life and reducing use of psychotropic medication have been reported (Birkenhager-Gillesse et al., 2018; McDermott et al., 2019; Noone et al., 2019). The nature of the intervention may vary greatly from creative interventions including music and art therapy, sensory interventions including aromatherapy and multi-sensory approaches, activity-based approaches such as exercise and psychological interventions such as reminiscence and cognitive stimulation therapy (Patel et al., 2014). Sensory interventions may be particularly beneficial for people in the later stages of dementia as they enable interaction without the need for verbal communication and capitalize on sensorimotor rather than intellectual abilities (Chung & Lai, 2002) at a time that PWD may be experiencing a decline in sight, smell or touch (Baker et al., 2003). Multisensory stimulation environments originated from the learning disability field but are being increasingly used for people with dementia. The intervention involves stimulation of the senses by the person's exploration of the environment, following a non-directive and facilitative approach (Lopez-Almela & Gomez-Conesa, 2011).

Music interventions for people with dementia

Interventions involving the arts have been reported to improve wellbeing, maintain a sense of identity, and promote social connectedness (Camic et al., 2016; Cousins et al., 2020). Music has been thought to be particularly beneficial as an ability to recall and respond to music is often retained when other cognitive abilities and memories are diminished (Baird & Samson 2015; Cuddy & Duffin, 2005). Music-based interventions for people with dementia have been found to reduce agitated behaviour (Pedersen et al., 2017), improve sleep patterns (Chan et al., 2010; Lindenmuth, 1992), stimulate communication and evoke autobiographical memories (Cammisuli et al., 2016). In addition, music-based interventions are relatively non-invasive and cost effective (Livingston et al., 2014).

Music therapy involves the professional use of tailored music within a therapeutic relationship to promote health and there is evidence to suggest it is effective in reducing BPSD including anxiety, depression and agitation (Gómez-Romero et al., 2017; Svansdottir & Snaedal, 2004; Vink et al., 2011). A meta-analysis looking at cognitive, behavioural and social/emotional measures found that music therapy improved the social-emotional state of people with dementia (Koger et al., 1999) and benefits may be maintained up to two months after the intervention is finished (Vink et al., 2011).

Gerdner's mid-range theory proposed that positive memories and feelings elicited by music therapy are soothing for an individual and will consequently lower stress and reduce BPSD (Gerdner, 1997). In line with the notion of person-centred care and relational theories of dementia (Nolan et al., 2004), it has been suggested that the positive effects of music therapy can be attributed to the active engagement of staff or relatives and their interaction during the intervention (Lawrence et al., 2012). Kitwood warned of the potential for depersonalisation and disempowerment when caring for an individual with a dementia diagnosis; personalised music therapy may enable more meaningful interactions that maintain the individual's 'personhood' (Kitwood, 1990).

Physiological responses

There is a growing research base around using physiological responses as a measure of an individual's experience, as it is widely accepted that activities or events cause changes in physiologic responses that are related to their emotional state. Cortisol, for example, has been deemed to be a reliable measure of stress and has been found to decrease in healthy adults following art making (Kaimal et al., 2016), in response to progressive relaxation (McKinney et al., 1997) and when music is played to patients experiencing presurgical stress (Miluk-Kolasa et al., 1994). Heart rate (HR) is also commonly used as an indicator of stress as HR decreases when the parasympathetic nervous system activity is dominant and increases when the sympathetic nerve activity is dominant, relating HR to the 'fight or flight' response (Kim et al., 2018). Interpreting HR can be complex; although increased HR can be linked to stress and negative health outcomes, it can also signify enjoyment, excitement, stimulation (Wilheim, 2006) and increased physical activity. For example, HR has been found to increase in children with learning disabilities during a Snoezelen intervention despite appearing engaged (Shapiro et al., 1997). Barrett suggested that conflicting physiological responses occur because there is no physiological fingerprint for emotions. In contrast to the view that emotions are related to a state in the body, she proposes that they are the individual's cultural interpretation of the moment, depending on previous learning (Barrett et al., 2016). Mauss and Robinson (2009) proposed that experiential, physiological and behavioural measures are all relevant to understanding emotion, therefore observations or additional outcome measures may be beneficial to gain a clearer understanding of the meaning behind physiological changes.

Physiological responses in people with dementia.

Self-report measures are often used as a way of understanding the effectiveness of psychosocial interventions, however they may be at risk of biased responses and become less reliable in the later stages of dementia when the individual may be less able to communicate how they are feeling. Physiological responses may offer an alternative way of understanding the person's experience as they do not rely on verbal or written communication. Although research in this area is still relatively new, there is emerging evidence to support their use. For example, Norberg et al. (2003) found an increase in heart rate and a reduction in respiration following specific songs during a music-based intervention.

Previous reviews

In a systematic review of music therapy interventions, Mcdermott et al. (2013) concluded that there was consistent evidence of short-term improvements in mood and behavioural disturbances, however did not find evidence of long-term effects. A more recent review by Thomas et al., (2018) critically reviewed studies based on the physiological responses of people with dementia during arts interventions. A major finding was the majority of research tends to be on music-based interventions and outcome measures focus around BPSD rather than physiological responses. They concluded that research examining physiological responses to the arts is limited with many studies having methodological limitations including small sample sizes and no control groups. There were a range of physiological measures reported including endocrinological outcomes, salivary chromogranin A (SCgA) and most commonly HR and heart rate variability (HRV).

Summary and rationale

Having access to psychosocial interventions is now regarded as integral to promoting wellbeing for people with dementia (WHO, 2019) and physiological measures are increasingly being considered as either an additional or alternative way of capturing the effect of these interventions. Although previous reviews have looked at the impact of psychosocial interventions on people with dementia (McDermott et al., 2013; Thomas, et al., 2018) to date there is no review looking specifically at how physiological responses relate to other measures of emotional state in this population. Gaining a clearer understanding of how physiological measures relate to the emotional state of people with dementia during psychosocial interventions will provide valuable information about the effect of the intervention when self-report measures are not feasible and inform the development of future interventions. This review examines research on psychosocial interventions for people with dementia that include both physiological measures and standardized measures of mood and/or wellbeing, which for the purpose of this review will be referred to as "emotional state".

The current review aims to answer the following questions:

1. What effect do psychosocial interventions have on the physiological responses and emotional states of people with dementia?

2. What do physiological responses tell us about the emotional states of people with dementia during and following psychosocial interventions?

Method

Literature search

Search terms were derived from papers identified from an initial search of literature in the area. The search terms covered four areas: dementia, physiological responses, psychosocial interventions and emotional state. The search terms can be seen below in Table 1.

The searches took place in January 2020 using four databases; Psychinfo, Pubmed, Cochrane Library and Medline. No specific timeframe was selected for the search in order to include all papers that would meet criteria. Following the initial search, reference lists were hand searched in order to identify any additional studies that may be relevant (Figure 2).

Inclusion and exclusion criteria

Due to the limited body of research in this area, all studies that met the following criteria were included: standardized measure of mood / wellbeing / quality of life; Physiological outcome measure; participants with any type dementia diagnosis; data collected whilst undertaking a psychosocial intervention. Exclusion criteria were: exposure to stimuli rather than an intervention; research not published in English. A total of 18 studies were included, however two studies have been listed as 6 and 6a as mood and physiological outcomes were listed in two separate papers relating to the same research study (Table 1).

Critical appraisal tool

The mixed methods appraisal tool (MMAT) (Appendix A) was used to critique the quality of the studies included in the review (Table 2). This tool is designed for the appraisal stage of reviews consisting of mixed methods studies.

Table 1

Table of Search Terms

Subject area	Search term
Dementia	(Dementia/ or (Dementia or Dementia's or Dementias or Dementias' or Demented or Alzheimer disease or Alzheimer or Alzheimer's or Alzheimer`s or Alzheimers)
Physiological responses	AND(Physiology OR Physiolog* OR Physiology* OR Heart Rate OR Heartrate OR Saliva OR Pupil OR Pupillometry OR Eye-tracking OR Eyetracking OR Eye tracking OR Galvanic Skin Response OR Electrodermal Activity OR Arousal OR Hormone* OR Hormonal)
Psychosocial interventions	AND(intervention OR group OR music* OR singing OR sessions OR exercise OR psychosocial OR Art OR "The Arts" OR music therapy)
Emotional state	AND(mood OR "emotional state" OR emotion* OR wellbeing OR well being OR well-being)

Figure 1

Flow Chart of Search Strategy

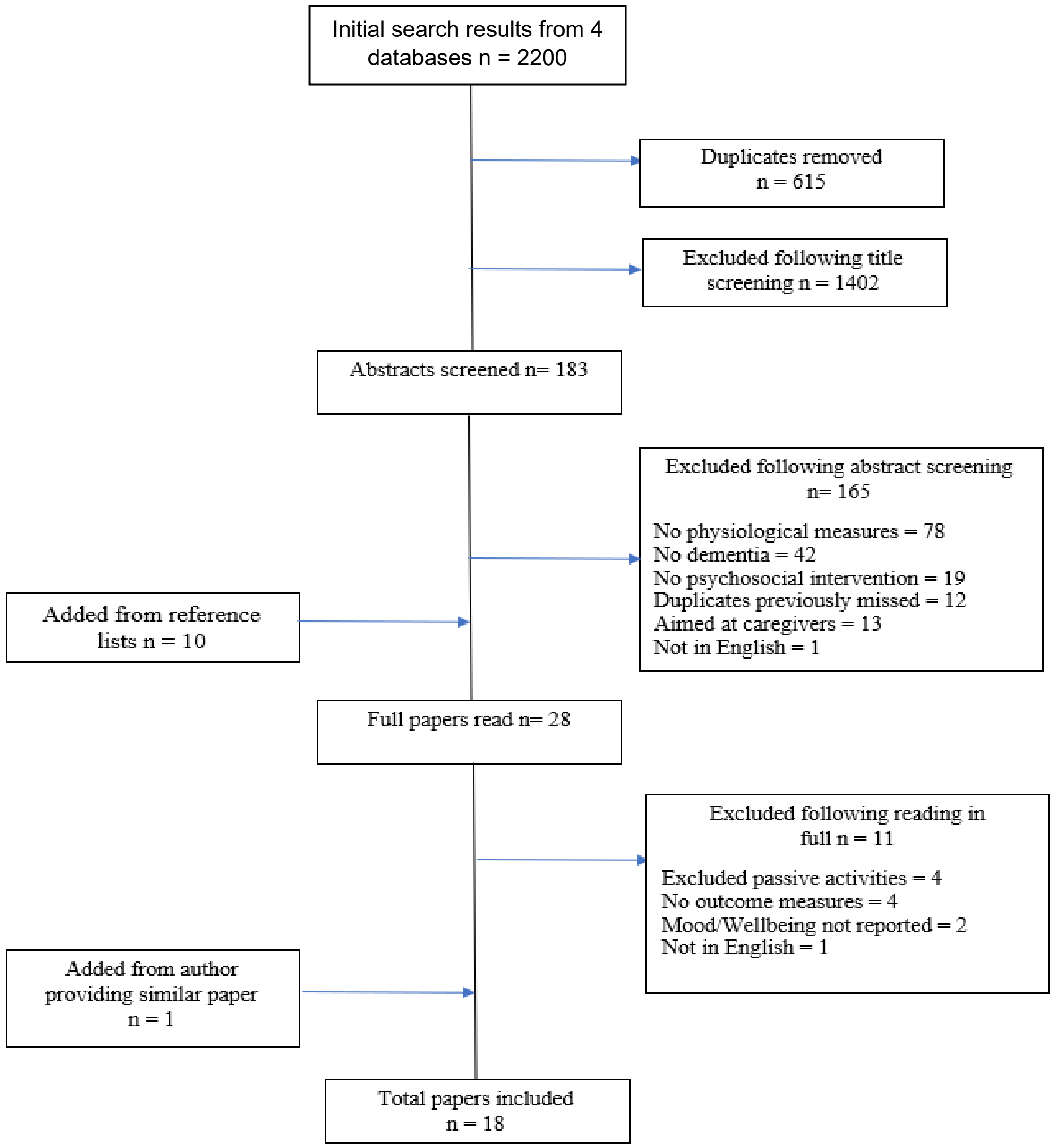

Table 2

Studies Included in the Review

	Author, date country	Participants (Gender) Mean age Attrition Diagnosis Severity Attrition	Type of intervention	Intervention	Setting	Design	Outcomes	Physiological measure results	Psychological measure results	Follow up
1	Pedrinolla et al. (2019) Italy	163 PWD (121 females) Age – 77 Attrition - 11 (6.7%) AD – (163) Severe	Indoor therapeutic garden	120 sessions, 2 hours 5 times per week for six months. Included free interaction, touching the plants and flowers.	AD day care centre	Randomised Controlled Trial, Control group standard care	Salivary cortisol Blood pressure NPI Dosage of quetiapine	Salivary – decrease at all four time points at time 2 ($p<0.001$) Blood pressure – reduction in systolic and diastolic blood pressure ($p < 0.001$)	NPI reduced (improvement) by more than 30 points ($p < 0.001$) Quetiapine reduced by 150mg in intervention group ($p < 0.001$). No effect size reported.	None
2	D'Cunha et al., **2019** Australia	25 PWD (17 females) Age - 84.6 Attrition - 3 (10%)	Art gallery Group intervention	6 sessions, 90 min art group per week for six weeks Facilitator presents pieces of art,	National Gallery of Art, Recruited from 5	Quasi experimental repeated measures design,	Salivary cortisol IL-6 Dem-QOL GDS	Salivary cortisol – waking to evening ratio higher at end of intervention ($p=0.033$). Returned to baseline at f/up	Dem-QOL – no change GDS – decreased post intervention ($p=0.015$) Returned to	Yes 6 week follow up

		AD (17) VaD (3) PDD (2) NK/Mixed (3) Moderate		includes 20 mins discussion. Six-week intervention	residential care homes	No control		IL-6 – no significant change	baseline at f/up. No effect size reported.	
3	Bourne et al., **2019** UK	10 PWD (4 females) Age - 76.5 Attrition - 7 (35%) AD (6) FTD (2) DLB (1) Mixed (1) Mild to moderate	Choral singing and art gallery Group intervention	1 session, 60 minute choral group already attended. Included physical warm up and singing. Art gallery group presented paintings, includes discussion, options to stretch and move physically.	Existing community singing group	Quasi-experimental design, Art group as activity based control	Saliva cortisol HR CWS VAS	Saliva assays – decrease in cortisol and testosterone following choral singing compared to art viewing (NS) HRV – increased during singing compared to other time periods. No change in HRV in art viewing	CWS – increased after singing ($p < 0.005$, r= -0.63) and NS change after art for PWD. VAS (stress) decreased after singing, increased after art (NS)	None
4	Maseda et al., **2018** Spain	21 PWD (15 females) Age -88.9 Attrition 1 (4.5%) Diagnosis -NS Severe	Multisensory stimulation environment (MSSE) and individualise d music sessions	24 sessions, 30 min sessions 2 x week for 12 weeks 1-1 MSSE in Snoezelen room or individualised music intervention	Older adult complex including day centre and residential care	Randomised longitudinal trial Active control	HR Oxygen saturation, Interact	HR and Oxygen saturation decreased for both groups, no significant difference between groups	Interact – increase in positive mood and behaviour: More happy / content ($p < 0.05$, d=-0.55), related to people well ($p < 0.05$, d = -0.39), attended to objects	None

			Individual interventions						(p < 0.05, d = -0.54), Enjoying self (p < 0.05, d = -0.54).	
5	de la Rubia Ortí, et al., **2018** Spain	25 PWD (19 females) Age –78.38 Attrition - 0 (0%) AD (25) Mild	Music therapy Group intervention	1 session of MT, 12 or 13 people in each group. Two MT activities within the session that lasted 30 minutes each.	Residential setting	Quasi experimental design No control group	Salivary cortisol HADS	Less cortisol following the intervention for those whose depression also decreased	Decrease in HADS (improvement) following intervention. Changes in both anxiety and depression p<0.001. No effect size reported.	None
6	Valdiglesias et al., **2016** Spain	22 PWD (15 females) Age – 88.4 Attrition - 4 (18.2%) Diagnosis -NS Severe	MSSE and individualised music intervention	16 sessions, 30 minute weekly sessions of either MSSE or music intervention	Specialist dementia centre residential	Quasi experimental design	SCgA CMAI CSDD RAID	SCgA showed no significant difference before and after 30 min intervention or in absence of intervention No significant difference pre/post intervention. No effect size reported.		Yes 8 week follow up
6a	Sanchez et al., **2016** Spain	22 PWD (15 females) Age – 88.4 Attrition - 4 (18.2%) Diagnosis - NS	MSSE and individualised music intervention	16 sessions, 30 minute weekly sessions of either MSSE or music intervention	Specialist dementia centre residential	Quasi experimental design	SCgA CMAI CSDD RAID		CMAI – decrease (improvement) for both groups (effect size med) RAID – decrease (improvement)for MSSE compared	Yes 8 week follow up

		Severe							to ind music $p < 0.05$ RAID and CSDD decreased in follow-up. CSDD and RAID for both groups effect size = large.	
7	Venturelli et al., **2016** Italy	80 PWD (58 females) Age – 84.75 Attrition – 0 (0%) AD (80) Severe	Exercise and cognitive based treatments Group intervention	60 sessions, 5 sessions per week for 3 months, one hour before sunset. Four conditions of cognitive training, exercise, both and no treatment.	Residential care home	Randomised study Both control and active control	Salivary cortisol NPI ABS	SC – decrease in Aerobic exercise (AE) group and AE + Cognitive training (CT) by 26% ($p < 0.05$). No change in CT and No treatment (NT) group. No effect size reported.	NPI and ABS decreased (improved) by 50% in AE and AE + CT groups ($p < 0.05$). No effect size reported. Changes in NPI and ABS correlated significantly with reduction in cortisol levels ($p < 0.05$).	No
8	Williams et al., **2016** US	36 PWD (17 females) Age - 80.39 Attrition - 10 (27.8%) Diagnosis -NS Mild to moderate	Memory day centre programme Group intervention	3 sessions a week for 3 months Programme included exercise, artistic activities, music, dancing, social interaction.	Day care centre in the community	Quasi experimental design No control group	Cortisol Blood pressure ICS PSS RAID DMPT	Cortisol decreased at 1 and 3 months ($p < 0.05$, effect size = 0.83). BP decreased but not significant	Decreased stress at 1 and 3 months ($p < 0.05$, n2=0.08, 0.10) No significant change in mood (DMPT, AD-RD) over time.	No

							AD-RD		RAID decrease (improvement) but not significant (p=0.12)	
9	Hsu et al., **2015** UK	17 PWD (16 females) Age – 84 Attrition - 3 (17.6%) AD (7) VaD (2) FTD (2) DLB (2) Mixed (1) NK (3) Moderate	Music therapy Individual intervention	22 sessions of 30 minutes, once a week for 5 months MT was video recorded and rated. Measures taken at baseline, 3, 5 and 7 months 9 in MT, 8 in standard care	Residential care homes	Randomised controlled feasibility study Control group receiving standard care	HR / HRV Skin conductance/temp Bodily acceleration NPI-NH DCM	Not reported in detail	NPI decreased (improved) in MT compared to standard care DCM – increase (improvement) in MT group, decrease in standard care Significant improvement for both, biggest change at baseline to 7 months. For NPI ($p < 0.05$, effect size = 2.32 large). For DCM biggest improvement between baseline and month 5 ($p < 0.05$, effect size = 2.48). Improvement continued at follow up for NPI	Yes 2 months follow up

10	Sakamoto et al., **2013** Japan	39 PWD (32 female) Age -80.7 Attrition – 0 (0%) AD (39) Severe	Active individualised music intervention	10 sessions, 30 minutes per week for 10 week Music intervention involved active participation in music, clapping, singing and dancing	Group residential homes and specialist dementia hospital	Quasi-experimental design Control group and passive music group	HR HF (HRV) BEHAVE-AD Faces scale	HR decreased in active and passive group HF decreased in control, increased in active and passive group	BEHAVE – reduction in BPSD Faces scale – improvement after passive session and intervention session ($p<0.01$) Improvements disappeared by follow up. No effect size reported.	Yes three weeks follow up
11	Chu et al., **2013** Taiwan	100 (53 female) Age – 82 Attrition – 4 (3.8%) Diagnosis - NS Mild (17) Moderate (62) Severe (21)	Music therapy Group intervention	6 session, 30 mins 2 x week for 3 weeks music therapy Intervention modified from Clair and Bernstein, 1990	Residential nursing homes	Prospective, randomised, parallel-group design Control group of standard care	Cortisol CSSD	Cortisol did not significantly decrease after MT intervention	Depression reduced in intervention group occurred immediately and was significant at f/up compared to baseline ($p < 0.01$, no effect size reported).	Yes 1 month follow up
12	Raglio et al., **2010** Italy	20 (15 females) Age – 85.5 Attrition – 0 (0%)	Music therapy Individual intervention	30 sessions, 2 x 30 min per week for 15 weeks	Residential nursing home	Randomised pilot study pre post	HR HRV NPI	HR unchanged PNN50 improved in 50% patients of MT group, non in control group	No difference between SC and MT group NPI scores after MT but depression in NPI significantly decreased in MT	No

		AD (6) VaD (5) Mixed (9) Moderate to severe		Randomly assigned to MT or standard care MT includes playing instruments and building non-verbal communication with therapist		Control group of standard care			group (p=0.021) No effect size reported.	
13	Suzuki et al., **2007** Japan	16 (14 females) Age – 85 Attrition – 0 (0%) AD (12) VaD (4) Moderate	Music therapy Group intervention	25 sessions, 1 hr 2 x week for 3 months MT including reality orientation, welcome song, hand bells	Geriatric hospital	Quasi experimental design Control group	SGcA Secretory immunoglobin A GBS BEHAVE-AD	Chromogranin A significantly decreased at 25th session ($p<0.05$) No significant change in Salivary IgA observed	GBS – Derangement, restlessness and worry significantly improved after MT ($p < 0.05$), no effect size reported, effects gone at f/u	Yes 1 month follow up
14	Baillon et al., **2005** UK Individual effects	20 PWD (12 females) Age – 75 Attrition – 5 (20%) AD (13) VaD (7) ARD (1)	Snoezelen and reminiscence Individual intervention	6 sessions, 3 x 40 min Snoezelen followed by 3 x 40 min reminiscence or vice versa Intervention followed guidelines to ensure they were distinct	Day unit connected to in-patient and day care facilities for people with dementia	Crossover randomised controlled trial Active control condition	HR ABMI	HR decreased by end of session in both interventions. Greatest effect in Snoezelen No significant difference between interventions	AMBI – decrease (improvement) in agitated behaviour in 14/20 people in S group and 6/20 in R group 6/20 showed increase in agitation after S group and 11/20 after R group	No

		Mixed (1) Uns (3) Moderate to severe							No effect size reported	
15	Suzuki et al., **2004** Japan	33 PWD (15 female) Age – 82 Attrition – 4 (12%) for saliva data AD (12) VaD (11) Severe	Music therapy Group intervention	16 sessions of MT 1 hour 2 x week for 8 weeks Singing and playing instruments	Dementia unit of hospital	Quasi experimental design Control group	SCgA MOSES	Salivary chromogranin levels significantly decreased in 16th session	MOSES irritability significantly decreased ($p < 0.05$). No effect. size reported	No
16	Baillon et al., **2004** UK Group effects	20 PWD (12 females) Age -73.5 Attrition - 5 (20%) AD (12) VaD (6) ARD (1) Uns (1) Severe	Snoezelen and reminiscence Individual intervention	6 sessions, 3 x min 40 min Snoezelen followed by 3 x 40 min reminiscence or vice versa	Day unit connected to in-patient and day care facilities for people with dementia	Crossover randomised controlled study Active control condition	HR ABMI Interact	HR decreased during session compare to before in both conditions– no significant difference between two interventions	AMBI – No significant changes between interventions ($p = 0.18$). Interact – Increase in positive items, no diff between interventions. No effect sizes reported	No

17	Heyn **2003** US	13 PWD (12 females) Age - 85.7 Attrition – 0 (0%) but intervention not adhered to by 4 (30%) AD (13) Moderate to severe	Multisensory exercise programme Group intervention	Initially 15 mins increased to 70 mins. 3 x week for 8 weeks	Residential nursing home	Quasi experimental design No control group	HR Blood pressure Weight CMR	HR – decrease in resting HR ($p < 0.05$). No change in BP and weight	CMR – 61% (8) showed improvements in their overall mood, 5 showed no significant difference or little improvement	Yes but only for cognitive decline

Diagnosis: AD=Alzheimer's dementia, ARD=Alcohol-related dementia, DLB=Dementia with Lewy bodies, FTD=Frontotemporal dementia, NS=Not stated, PDD=Parkinson's, VaD=Vascular dementia

Measures: ABMI=Agitation behaviour mapping instrument, ABS=Agitated behaviour scale, AD-RD=Alzheimer's disease and related disorders mood scale, BEHAVE-AD=Behavioural pathology in Alzheimer's disease, CMAI=Cohen-Mansfield agitation inventory, CMR=Caregiver mood report, CSSD=Cornell scale for depression in dementia, CWS=Canterbury wellbeing scales, DEM-QOL=Health measure of quality of life for people with dementia, DCM=Dementia care mapping, DMPT=Dementia mood picture test, Faces scale=Emotion assessment tool, GBS=Gottfries-Brane-Steen scale, GDS=Global deterioration scale, HADS=Hospital anxiety and depression scale, HF=High frequency, HR=Heart rate, HRV=Heart rate variability, ICS=Index of clinical stress, IL-6=Interleukin 6, Interact=Scale to observe effects of MMSE, MOSES=Multidimensional Observation Scale for Elderly Subjects, NK=Not known, NPI=Neuropsychiatric inventory, NPI-NH=Neuropsychiatric inventory for residential homes, PNN50=Form of HRV correlated with parasympathetic activity, PSS=Perceived stress scale, RAID=Rating of anxiety in dementia, SCgA=Salivary chromogranin A, VAS=Visual analogue scales

Table 3

Quality appraisal table

Randomised studies

Study number	Author and date	2.1 Is randomization appropriately performed?	2.2. Are the groups comparable at baseline	2.3. Are there complete outcome data?	2.4. Are outcome assessors blinded to the intervention provided?	2.5 Did the participants adhere to the assigned intervention?
1	Pedrinolla et al. (2019) Italy	Yes and described	Yes no significant difference between groups	11 participants dropped out from 163 (6.7% attrition)	Single blind	Yes
4	Maseda et al., **2018**	Yes and described use of computer generated numbers	Yes compared demographics	21/22 participants provided data (4.5% attrition)	No	Yes
6 and 6a	Valdiglesias et al., **2016**	Yes and described use of computer generated numbers	Yes baseline groups described as homogenous	18/22 completed due to drop out (n=1) and death (n=3). (18.2% attrition)	No	Yes
7	Venturelli et al., **2016** Italy	Not described but states randomisation took place	Yes groups similar	Yes 100% completion	Single blind	Between 75 and 85% adherence

9	Hsu et al., **2015** UK	Yes and described	Yes groups similar	14/17 completed. Three left exp group. (17.6% attrition)	No	Yes
10	Sakamoto et al., **2013**	Stated but not described	Yes used stratified randomisation	39 completed. (0% attrition).	Yes	Yes
11	Chu et al., **2013**	Yes and described	Yes no significant difference between groups	100/104 completed study. (3.8% attrition).	Yes	Yes protocols were used
12	Raglio et al., **2010**	Yes programme used was described	Yes no significant differences between groups	Yes 100% completion	Yes	Yes
14	Baillon et al., **2005**	Yes described use of sealed envelope selection	Unclear, variation in both groups, no comparisons made	Started at 25, 20 completed. (20% attrition)	No	Yes
16	Baillon et al., **2004**	Yes described use of sealed envelope selection	Unclear, no comparison made	Started at 25, 20 completed. (20% attrition)	No	Yes

Quantitative non-randomised studies

Study number	Author and date	3.1 Are the participants representative of the target population?	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	3.3. Are there complete outcome data?	3.4. Are the confounders accounted for in the design and analysis?	3.5 During the study period, is the intervention administered (or exposure occurred) as intended?
3	Bourne et al., **2019**	Convenience sample of mild to mod dementia, predominantly female, no diversity from white British/European	Yes, although difficulty collecting data from saliva	13/20 attended both sessions. Not complete data set for saliva	Confounding variables limited by using already established singing group	Yes
5	de la Rubia Ortí, et al.,	Yes, identified through services, all eligible participants included	Yes	Yes	Yes medication and education level accounted for	Yes
8	Williams et al., **2016**	Yes convenience sample as people were naturally enrolled in day centre	Yes, wide range of measures	26/36 completed (27.8% attrition)	Yes, excluded in medication change, time spent in day centre used as co-variate in analysis	Yes
13	Suzuki et al., **2007**	Unclear naturally occurring sample, no mention of ethnicity	Yes there was a range of measures included	All completed, one person missing from three of sessions	Groups were matched, nurses blinded	Yes used a protocol
15	Suzuki et al., **2004**	Unclear naturally occurring sample from residential setting but recruitment process not described	Yes	Only 6/10 in experimental group provided saliva	No mention of medication or other potential confounding variables	Yes

17	Heyn **2003**	Almost entirely female, all middle class and white participants	Engagement and mood scale required further validation	All completed measures	No description of this	No - 9/13 people engaged in "more than half" of intervention

Quantitative descriptive

Study number	Author and date	4.1. Is the sampling strategy relevant to address the research question?	4.2. Is the sample representative of the target population?	4.3. Are the measurements appropriate?	4.4. Is the risk of nonresponse bias low	4.5. Is the statistical analysis appropriate to answer the research question?
2	D'Cunha et al., **2019**	In part, not randomised	Full sample description but no mention of inclusion/exclusion or attempts to be representative	Only 22/25 able to provide cortisol samples. GDS thought to have high validity	3/28 dropped out due to illness (10% attrition)	Yes

Results

Study design

Nine of the studies were quasi-experimental designs (2, 3, 5, 6, 6a, 8, 10, 13, 17). Recruitment within these studies tended to be convenience samples based on the availability within the setting and data were collected pre and post intervention. The remaining eight studies used randomization of participants to conditions (4, 7, 9, 11, 12, 14, 15, 16). The use of control groups varied across the sample. Seven of the studies incorporated active control conditions (3, 4, 6, 6a, 12, 14, 16), two used both active and standard care controls (7,10) and five used standard care as a control condition (1, 9, 11, 12, 13). There was no control group in four of the studies (2, 5, 8, 17). Ten studies (1, 3, 4, 5, 7, 8, 12, 14, 15, 16) did not collect follow-up data, missing the opportunity to observe longitudinal effects. Six collected follow-up data after three weeks (10), one month (11, 13), six weeks (2), eight weeks (6, 6a) and one only collected data on cognition at follow up (17).

Sample

The number of participants included ranged from 13 (17) to 100 (11). All except one (8) had more female than male participants and the average age of the participants ranged from 73.5 – 88.9 years. Most of the papers derived from areas that would be considered Western: Australia (2), UK (3, 9, 14, 16), USA (8, 17), Spain (4, 5, 6, 6a) and Italy (1, 9, 14). Three originated from Japan (10, 13, 15) and one from Taiwan (11). The ethnicity of participants was not always included (1, 4, 5, 6, 6a, 7, 9, 10, 11, 12, 14, 15, 16). For those where ethnicity was included, the population tended to be white or nearly entirely white (17, 3, 8). One stated that participants were Japanese (13) and another stated that 'most' (68%) were Australian with no further information provided (2).

The sample included people at all stages of dementia with the most studies including participants with moderate to severe or severe dementia (1, 4, 6, 7, 10, 12, 14, 15, 16). Three studies only included participants with moderate dementia (2, 9, 13) and the remaining were mild (5), mild-moderate (3, 8) or mixed (11).

The majority of the papers described monitoring medication throughout the intervention (1, 3, 5, 6, 6a, 7, 8, 10, 11, 14, 16, 17) whilst the remaining five studies did not mention medication (2, 4, 9, 13, 15). Some provided specific information such as stating all participant were taking the same anticholinesterase (5), indicating medication was stable for one month (6,6a), describing the medication they were taking (7), or clearly specifying that there were no significant changes to medication (1,10,11). One study commented on a participant starting antipsychotics as the trial began and decided to include them (8) whilst two removed any participants with significant changes to medication from the study (14, 16).

Recruitment

The samples came from a range of settings including residential care homes (2, 4, 5, 6, 6a, 7, 9, 10, 11, 12, 17), day care centres (1, 8) and hospitals (13, 14, 15, 16). One sample was recruited from an existing community group for people with dementia (3). All participants were recruited through convenience samples with most giving little information about the recruitment process other than stating that individuals were recruited from the relevant setting. Two studies described the process of obtaining the sample by narrowing an initially larger number of participants using eligibility criteria (10, 11) and in one instance the process involved participants being identified by the ward manager (16).

Interventions

Ten studies (3, 4, 5, 6, 6a, 9, 10, 11, 12, 13, 15) included music interventions. One intervention used music involving active participation (10) and six others involved music therapy (5, 9, 11, 12, 13, 15). Two studies compared individualized music interventions to Multi-Sensory Stimulation Exercise (4, 6, 6a) and one compared a choral group to an art gallery intervention (3). Other studies included an art gallery intervention (2), a therapeutic indoor garden (1), a multi-sensory exercise programme (17) and a multi-modal day programme which included a range of activities including artistic activities and physical exercise (8). One study compared exercise and cognitive based treatments (7) and two studies compared Snoezelen and reminiscence (14, 16).

The duration of the intervention and time spent in each session varied greatly across the studies. They ranged from standalone sessions that lasted for one hour (3, 5), to a more intensive program of 65 sessions five times a week for three months (7). The most common intervention length was six sessions (2, 14, 16). Session length varied from 15 minutes (17) to days of a day centre programme, although the number of hours was not specified (8).

The majority of the music interventions were delivered by qualified music therapists (5, 8, 9, 10, 11, 12, 15) or music therapy trainees (13). One study stated that professionals involved in delivering the interventions included nurses and occupational therapists (10). Other interventions were delivered by occupational therapists (4), exercise physiologist (17), physiotherapist (7) and an experienced choral conductor and gallery educator (3). Two studies described the facilitators as research staff with no further information regarding training (14, 16), one did not mention the profession but stated that appropriate training was provided (2) and one study (with two papers associated) did not state the profession at all (6,6a). In one intervention participants were given the option of interacting with the environment alone, although session managers were given the option of taking part (1).

Outcome measures

Measures of emotional state

There were a wide range of measures related to emotional state. This was indicative of a broad range of experiences including stress, quality of life, mood and wellbeing. The neuropsychiatric inventory for residential homes (NPI) was the most frequently used measure in four studies (1, 7, 9, 12). The NPI considers the frequency, severity and level of disruptiveness to staff in twelve areas related to behavioural symptoms and mood. The Interact Scale, designed specifically for observations of mood during MSSE (4, 16), the Rating for Anxiety in Dementia (RAID) (6, 6a, 8), Cornell Scale for Depression (CSDD)(6, 6a, 11) and the Agitation Behaviour Mapping Instrument (ABMI)(14, 16) were also used in the sample.

For the studies focusing on people with a mild-moderate diagnosis of dementia, self-report measures were often used. Bourne et al. (3) used the Canterbury Wellbeing Scale (CWS) which asks people to respond how they feel on a Likert-style scale of 0-100 with five subscales including happiness and wellness (3). Another study used the hospital anxiety and depression scale (HADS) which asks people to rate their feelings on scales related to anxiety and depression (5). Most studies used more than one measure in order to observe different outcomes of interest, for example Williams et al., used specific measures to look at stress (Perceived Stress Scale (PSS)), anxiety (RAID) and Mood (Dementia Mood Picture Test (DMPT), Alzheimer's Disease – Related Disorders (AD-RD)) (8).

Studies that included people who were in more advanced stages of dementia tended to use observational measures rated by caregivers or researchers. For example, one study used Dementia Care Mapping (DCM) (9) which is an observational tool used within institutionalized settings that supports staff to observe mood, behaviours, engagement and interactions with staff, however this study did not report on the physiological responses in detail. Sakamoto et al., (2013) used the Faces Scale which is used by professionals to assess emotion when the person is unable to express how they are feeling (10).

Findings from emotional state measures

All studies concluded that psychosocial interventions had a positive impact on at least one measure of mood and/or wellbeing of people with dementia regardless of the number of sessions. However, the variation in the quality of the studies means it is not possible to draw firm conclusions. Some studies used measures that are designed to identify changes in a broad range of symptoms related to dementia such as the NPI (Cummings et al., 1994) (1, 7, 9), the Interact Scale (Baker & Dowling., 1995) (4, 16), the Behavioural Pathology in Alzheimer's Disease Rating Scale (BEHAVE-AD) (Reisberg et al., 1987) (10), Gottfries-Brane-Steen Scale (GBS) (Homma et al., 1991) (13), Multidimensional Observation Scale for Elderly Subjects (MOSES) (Helmes et al., 1987) (15) or the Caregiver Mood Report (Heyn, 2003) during which the PWD's mood is rated by their caregiver (17) . All the studies using these wide-reaching measures found a statistically significant improvement (1, 4, 7, 9, 10, 13, 15, 16, 17). Two of these studies also reported large effect sizes (4, 9). Six of these studies were randomised (1, 4, 7, 9, 10, 16) and three of those had large sample sizes and blinded researches (1, 7, 10). Some studies commented on the specific areas of change, for example Suzuki et al., (2007) (13) identified restlessness and worry as the areas that had the most significant reduction.

Those that specifically looked at measures of depression showed significant improvements following a non-randomised art gallery intervention (2) and randomised music therapy interventions (11, 12). De la Rubia et al., (2018) found a significant reduction in depression and anxiety following their group music therapy intervention (5) whilst Williams et al., (2016) found a significant reduction in stress in their sample of 26 but no significant changes in anxiety or depression (8). Neither of these studies were randomised, however both accounted for confounding variables and used a representative sample. Baillon et al., (2004) (16) found no group effects on agitation following their randomised comparison of Snoezelen and reminiscence, however in a later study used the same data to look at individual changes and found that there was a significant decrease in agitated behaviour for 14/20 people (14). Sanchez et al., (2016) found a significant reduction in agitation measured by the ABMI for both MSSE and individualised music sessions and a reduction in anxiety in the MMSE group (6a). This was a randomised study with homogenous baseline groups; however, researchers were not blinded. Wellbeing scores were found to improve significantly directly after a one-off singing session with ten participants. This study was not randomised but had accounted for confounding variables (3).

Some studies showed improvement in some areas but not others, for example D'Cunha et al (2) found a significant decrease in GDS scores but no change in the Dem-QOL following their art gallery intervention. Baillon et al., (16) found an increase in positive responses in the Interact, however no change in levels of agitation.

Only six of the studies had follow-up measures of mood and/or wellbeing (2, 6a, 9, 10, 11, 13). In three of these studies, improvements had returned to baseline at follow-up (2, 10, 13). Chu et al., (2013) found that a reduction in depression scores was sustained at 1-month follow up following a course of music therapy (11) and Hsu found a large effect size in NPI scores that remained consistently low two months after the intervention ended (9). Sanchez et al., (2016) found further improvements in depression scores (CDSS) and agitation (RAID) at eight-week follow-up however they commented this could be attributed to the progression of dementia or the final measures being taken in summer. All of these were randomised studies (6a, 9, 11), however only Chu et al., used blinded researchers and a larger sample (11).

Physiological measures

All of the studies featured either heart rate (HR), heart rate variability (HRV) or salivary assays. Three studies included blood pressure (1 ,8, 17) and one study used skin conductance and bodily acceleration in addition to HR and HRV, but did not report on the results in detail (9).

Heart rate / heart rate variability. HR or HRV featured in eight of the studies (3, 4, 9, 10, 12, 14, 16, 17). Measures were either taken pre-post the entire intervention, pre-post after an intervention session, or compared activity during the intervention to another condition. In Baillon's (2004) study (16), a reduction in HR was related to an increase in observed positive changes in mood following both Snoezelen and MMSE. There was no significant change in the group for anxiety (AMBI), however when looking at individual results in a follow-up study (14) the reduction in HR was associated with a decrease in anxiety for 14/20 people in the Snoezelen group and 6/20 people in the reminiscence group. It should be noted that although these were randomized studies, only 80 percent of participants completed the intervention.

In a small scale but high-quality randomised study, Raglio et al., (2010) (12) found HRV and depression scores improved in 50 percent of participants undertaking music therapy whilst no change occurred in the standard care group. In another small-scale randomized comparison of music sessions and MSSE, Maseda et al., (4) found HR decreased, oxygen saturation increased and there was an increase in observed positive mood and behaviour following both interventions.

Sakamoto et al., (10) (2013) divided the results from their slightly larger scale high-quality randomised study into short and long-term outcomes. Looking at short term outcomes, they found a significant increase in HRV at the end of the sessions for both the active control and indivdiualised music therapy group in addition to an increased rating of "comfortable mood" identified by the Faces Scale, which was statistically significant for the intervention group. The long-term results showed a decrease in five subscales (affective disturbance, anxieties and phobias, paranoid ideation aggressiveness and activity disturbance) of the BEHAVE-AD in the intervention group compared to only two in the active control. Activity and affect disturbance scores increased in the standard care control condition. Three weeks after the intervention was complete, BPSD had significantly decreased in the intervention and active control with no change in the control group. Bourne et al., (3) observed changes in HRV during a choral group as well as improvements on the CWS when compared to an art viewing group.

Salivary cortisol. Results from cortisol samples varied greatly across the studies with some reporting on long-term changes in cortisol levels following their interventions, others looking at more immediate changes. Williams et al. (2016) found a statistically significant decrease in stress scores in addition to a large effect size for 100 participants following a three month day centre programme (8), however they did not find any significant changes in mood measures. A non-randomised study by D'cunha et al., (2019) (2) looked at cortisol levels four times a day during an art gallery intervention and emphasised the importance of measuring cortisol at different time points in the diurnal cortisol rhythm. They found significant changes in the ratio of morning to evening cortisol levels post intervention and a reduction in symptoms of depression, however these results were not sustained at six-week follow up and samples were only taken from 80% of participants. They also looked at Interleukin-6 which has been found to be elevated in people with dementia and associated with cognitive decline and abnormal HPA axis but found no changes following the intervention.

Two larger scale high quality randomised controlled studies by Venturelli et al., (2016) and Pedrinolla et al., (2019) found related changes in cortisol and mood measures. Venturelli et al., (7) also measured cortisol over four time points and found a significant decrease following a 12-week intervention for those in an aerobic exercise group or a combination of exercise and cognitive training. These groups also had a 50 percent decrease in NPI and ABS scores suggesting cortisol changes may be a good indicator of emotional state. There was no significant change for those in the control condition or cognitive training alone. Following a six-month therapeutic garden intervention, Pedrinolla et al., (2019) found a decrease in cortisol at all four time points, a reduction in NPI scores and a reduction of 150mg of Quetiapine in the experimental group (1).

Some studies collected cortisol measures once at each data collection point (before, mid-point and following the intervention (2, 11)) others observed changes before and immediately after the individual intervention session (3. 5). Three studies collected saliva at multiple points in the day (1, 7, 8).

De la Rubia et al. (5) found that levels of cortisol and HADS scores decreased following individual music therapy in their study of 25 participants. Looking at the anxiety and depression scores individually, they found that decreases in cortisol correlated with decreases in depression scores, however the lowest levels of cortisol were associated with the smallest anxiety decrease. This suggests that a reduction in cortisol levels may be a better indicator of improving mood than anxiety reducing. Others found no significant changes in cortisol levels regardless of changes in emotional state. Chu et al., (11) undertook a randomised study of over 100 participants observing cortisol levels and depression scores over a six-session music therapy intervention. They predicted that cortisol levels would decrease if depression scores reduced, however they found no change in cortisol levels despite a change in depression scores. A study with 20 participants by Bourne et al., (3) also found no significant change in cortisol levels following one session of choral singing or art viewing.

Salivary chromogranin A (SCgA)[1]. It has been suggested that salivary CgA reflects psychological stress more quickly and sensitively than cortisol (Nakane et al., 1998). Four of the studies used SCgA as an indicator of psychological stress (6, 6a, 13, 15) however three studies either had a small sample size (6, 6a, 13) or were only able to collect a reduced saliva sample (15). Two studies looked at long-term changes of SCgA pre and post intervention. Suzuki et al., (2004) found SCgA levels and irritability scores on the MOSES both reduced by the sixteenth session of music therapy (15). In a follow-up longer term study, the authors found a decrease in SCgA by the 25th session of music therapy was associated with a significant improvement in derangement, restlessness and worry. At one-month post-intervention these benefits were not maintained (13). This study also reported no significant changes in salivary IgA over the intervention period and suggested that the intervention reduced stress but did not activate the ANS. Valdiglesias et al., (2016) and Sanchez et al., (2016) reported on the same study across two papers including short-term changes in CSgA levels (6, 6a). They found no significant change in SCgA levels after intervention sessions of individualized music sessions or MSSE sessions. There was however a longer-term decrease in scores in anxiety (RAID) in the MSSE group and agitation (CMAI) in both intervention groups. It could be therefore argued that SCgA is not a good measure of mood change, however it is hard to compare short-term physiological measures to long-term measures of mood.

Blood pressure. Three of the studies observed changes in blood pressure (1, 8, 17). Williams et al., (2016) (8) used blood pressure as a measure of arousal over a memory service day programme. They found that although systolic and diastolic blood pressure decreased three months into the day programme, the changes were not significant. There was, however

[1] SGcA is is an acidic phosphorylated secretory protein used as an indicator of SNS activity

a significant reduction in cortisol and self-perceived stress scores. Pedrinolla et al., (2019) found that blood pressure significantly decreased following a therapeutic garden intervention. This occurred alongside a significant decrease in salivary cortisol, reduction in NPI scores and a decrease in the administration of Quetiapine indicating reduced agitation. The authors concluded the reduction in blood pressure contributed to a picture of reduced stress in the only large scale randomised study observing blood pressure. In contrast, no significant change in blood pressure was found when comparing before and after an eight-week multisensory exercise programme, despite most participants showing improvements in their mood (17).

Discussion

The effect of psychosocial interventions on measures of emotional state and physiology

All the studies included in the review concluded that psychosocial interventions had a positive impact on at least one measure of emotional state, however there was variation in the quality of the studies. The most commonly used measures were those that incorporated a broad range of psychiatric symptoms such as the NPI (Cummings et al., 1994) which includes 12 subscales of behavioural symptoms. These measures demonstrated improvements in all of the studies they were used in. Improvements occurred across a broad range of interventions including a therapeutic garden, MSSE, exercise and cognitive training, individual and group music therapy, Snoezelen, reminiscence and multisensory exercise. This indicates that there is a common factor across these interventions that has positive implications for reducing BPSD.

Considering mood more specifically, all but one of the studies measuring depression found a significant improvement in depression scores following an art gallery or music therapy intervention. There was no significant change in anxiety or depression following a day centre intervention, however participants in this group did show a significant decrease in stress. Agitation is thought to occur in approximately 90% of people with advanced dementia (Tariot, 2003). The research included in this review indicates that interventions may have a positive impact on agitation levels (6a), however research by Baillon et al., (2004, 2005) demonstrated that this is likely to depend largely on the individual and highlights the importance of a person-centred approach to each individual rather than a blanket rule for all. Only one study used a quality of life measure and found non-significant results, therefore there is little evidence for quality of life measures within this review, however it could be argued that quality of life is improved via the more specific outcomes previously reported.

The results of physiological measures were more mixed than those pertaining to the emotional state of participants, however resting HR was found to decrease following a multisensory exercise programme (Heyn, 2003), MSSE, individualized music (Maseda et al., 2018), Snoezelen and reminiscence interventions (Baillon et al., 2004, Baillon et al., 2005). Raglio et al. (2010) found that there was no change in HR following their music therapy intervention, however there was an increase (improvement) in HRV for 50% of participants. This was not found to be significant when looking at group effects. A singing group (Bourne et al., 2019) and individualized music therapy (Pedrinolla et al., 2019) were both found to significantly increase HRV which is associated with heart health and increased activity in the executive brain regions and may have implications for maintaining cognition (Thayer et al., 2012). Neither study reported on long-term changes in HRV.

The studies measuring salivary cortisol demonstrated that psychosocial interventions may reduce cortisol levels, however concerns were raised about small sample sizes due to difficulty obtaining saliva and how dementia may be impacting the individual's physiology. Significant reductions in cortisol were associated with an improvement in mood or wellbeing measures and occurred during a broad range of interventions including a day centre programme (Williams et al., 2016), group music therapy (de la Rubia Orti, 2018), art gallery intervention (D'Chuna et al., 2019), aerobic exercise, cognitive training (Venturelli et al., 2016) or following a therapeutic garden intervention (Pedrinolla et al., 2019). It should be noted, however, only one of these studies had an active control (Venturelli et al., 2016) and therefore it is difficult to tease apart the impact of the specific activity from any other.

There were no changes in salivary cortisol levels following a choral group (Bourne et al., 2019) or following a three-week music therapy intervention (Chu et al., 2013). Chu et al. (2013) questioned the use of cortisol due to the individual variation of cortisol and potential dysregulation of the hypothalamic-pituitary-adrenal axis in patients with dementia. They also suggested that their three week intervention may not have been long enough to observe changes. Most of the studies that observed significant changes were longer-term interventions, some with larger sample sizes (Pedrinolla et al., 2019, de la Rubia Orti et al., 2018, Venturelli et al., 2016, Williams et al., 2016). However, De la Rubia et al. (2018) found significant changes in cortisol levels immediately after just one session of their music therapy intervention.

Despite all the studies observing changes in SCgA being music interventions of a similar duration, results were mixed. There was a reduction in SCgA and an improvement on measures related to agitation in two of the three studies post intervention (Suzuki et al., 2004, Suzuki et al., 2007). The difficulty of expecting this population to adhere to a salivary collection protocol and the inconsistent results suggest that saliva may not a reliable and feasible measure within this population.

What physiological responses tell us about the emotional state of people with dementia during psychosocial interventions

Changes in both HR and HRV were associated with improvements in mood and wellbeing measures following a range of interventions including a singing group, MSSE, Snoezelen, reminiscence therapy, music therapy suggesting that these may be useful for capturing the experience of a PWD. Improvements in mood and behaviour were associated with a decrease in HR in all studies included, with the exception of a 15-week individual music therapy intervention (Raglio et al., 2010). The impact of individual differences was highlighted by Baillon et al. (2004, 2005) who did not find a group effect of changes in mood measures corresponding to a decrease in HR, however reported that 14/20 participants showed a significant decrease in agitation when looking at individual changes. It should also be noted that all included studies included participants in the moderate to severe stage of dementia. Improvements in mood and wellbeing measures were associated with an increase in HRV during all three music interventions in participants with mild, moderate and severe stages of dementia indicating that HRV shows promise as a measure of the emotional experience of individuals during psychosocial interventions.

In line with previous research suggesting that salivary cortisol is linked to a range of emotional states (Cruess et al., 2000; Van Eck et al., 1996), this review found that a decrease in salivary cortisol was associated with decreases in BPSD, depression, agitation and stress. Cortisol is most commonly used as a measure of stress and results were inconsistent when thinking about what cortisol might be telling us about mood more specifically. Decreases in salivary cortisol were found to correspond with a reduction in depression scores following an art intervention and group music therapy, however also decreased in the absence of changes in depression following a day centre intervention and did not decrease despite improvements in depression scores following music therapy (Williams et al., 2016). De la Rubia et al., (2018) also concluded that cortisol does seem to play a role in the variation of anxiety and depression. These mixed results indicate that Saliva is not a robust indicator of depression but may be a more consistent measure of stress or useful for providing additional information in conjunction with other measures. Difficulties in collecting saliva in this client group were highlighted in some of the studies. One problematic aspect is that individuals are encouraged to follow a saliva collection protocol and it is hard to monitor who has adhered to the protocol, which may begin hours before the intervention (D'Cunha et al., 2019).

A decrease in SCgA occurred alongside a reduction in anxiety related scores following two relatively long-term music therapy interventions for people with moderate to severe dementia. However, these results were not replicated in a similar length MSSE and individualized music comparison for people with severe dementia raising questions around the reliability of SCgA as a measure of mood. Research has proposed that SCgA may be a more reliable reflection of SNS activity as it is not influenced by circadian variation (Valdiglesias et al., 2016), however more studies would need to be considered with larger sample sizes to draw further conclusions.

Methodological considerations

Design

Due to the limited research base, all studies that included measures of emotional state and physiological responses were included in the review, resulting in a variety of research designs. Overall, external validity was a concern due to small sample sizes making it difficult to generalize findings to the wider population. Although there were some larger scale randomized trials included, the majority consisted of under 25 or fewer participants, therefore it is difficult to generalize the results to the wider population. Although sample sizes were small, the majority of the studies randomized participants to conditions which adds strength to the research, however five of the nine randomized studies did not blind researchers, meaning there is potential for overestimation or underestimation of treatment effects. In addition, recruitment strategies were often unclear raising questions about selector bias as it is possible researchers may have been selecting participants who they felt would be more likely to respond to treatment.

Five of the studies did not have a control group therefore it is difficult to tease apart the effect of the intervention from changes in mood or physiology that might have occurred naturally. It is positive that only two studies chose treatment as usual as the control condition as this makes it difficult to identify whether it was the specific intervention that was having an impact or whether changes are due to increased stimulation or activity that may occur in any intervention. In addition, treatment as usual is rarely monitored or supervised (Guidi et al., 2018).

The attrition rate was based on the number of people who withdrew from the study during the intervention period and were therefore not included in the final data analysis. There was a moderately high attrition rate of up to 28 percent (Williams et al., 2016), which is likely to have an impact on the results as it may be hypothesized that those that did not continue were not feeling the benefits of the programme. Having said that, attrition rates are expected to be high in this population due to high rates of co-morbid physical health problems and it is a strength that this was clearly reported in most of the research. Reasons for people not completing the intervention were given in some cases and these included worsening condition (Pedrinolla et al., 2019), death (Valdiglesias et al., 2016), hospitalisation and loss of interest (Chu et al., 2013). Finally, the lack of follow-up data incorporated makes it difficult to identify any long-lasting changes to the individual's physiology or wellbeing/mood.

Participants

Although the male to female ratio within this review is similar to what may be expected in the general population over 65 (ONS, 2018), the samples were heavily dominated by female participants making it more difficult to generalize the results to the males. The majority of the studies took place in countries considered as Western and there was a lack of ethnic diversity included in the studies which make it hard to extrapolate findings to black and ethnic minority groups. It is also widely acknowledged that minority ethnic groups are less likely to access mainstream services (Mukadam et al., 2013) therefore research needs to include more diverse samples to enable development of interventions that are suitable for a broader spectrum of people in order to encourage access. There are a broad range of diagnoses and severity of dementia included under the umbrella term of dementia. Research has shown that the impact of a dementia diagnosis is very individual even within the various sub-types and most of the studies included in this review had a range of diagnoses included making it difficult to draw conclusions from the participants as a homogenous group.

Interventions

Use of measures. The NPI was the most frequently used measure or emotional state and has been used in a number of previous studies and been found to be valid, reliable and sensitive to change (Raglio et al., 2010; Ridder et al., 2009). However, the description of measuring “disruptiveness to staff” is unhelpful as it is derogatory and positions the PWD as an inconvenience. Information on the validity and reliability of measures were included in all of the studies, only one study by Heyn (2003) suggested the measure of caregiver mood report (CMR) needed further validation and reliability testing. A review by Vink and Hanser (2018) found that the definitions of music-based and music therapy interventions are inconsistent and protocols are not described in enough detail to be replicated accurately. The information around protocols and session content in the current review were mixed with some clearly stating the intervention and other studies being very vague making it impossible to replicate.

Clinical Implications

Although it is difficult to draw firm conclusions this review highlighted that a broad range of psychosocial interventions can have positive impacts on the mood and physiology of people with a dementia diagnosis. Finding personally meaningful and indivdiualised interventions is likely to enhance these benefits by maintaining the individuals personhood in addition to the general impact of the increased stimulation and interaction. The review does indicate promise in identifying a relationship between measures of emotional state and physiological responses in this population. Consequently, physiological responses may be used to identify changes in emotional state, particularly if used as part of a wider picture along with other sources of information. HR and HRV appears to be the most robust measure of positive changes in emotional state within the review, however teasing apart the negative impact of stress associated with an increased heart rate and the positive impact of arousal continues to be a challenge. Salivary cortisol and SCgA measures also showed promise, however results were less consistent and there are challenges in data collections for this client group.

Implications for future research

Further research is needed in this area to establish a clearer understanding of how physiological responses relate to the emotional state of people with dementia during psychosocial interventions. Future research should include power calculations and use larger sample sizes if needed, to increase generalisability. Although double blinding may not be possible, future research should ensure single blinding of researchers and randomisation. "In the moment" interventions are essential for people with dementia as they may not be able to recall sessions that had occurred in the past, however there is a dearth of research considering long-term effects of interventions on the physiology of this group and this review found there were long-term changes in half of the studies. In addition, only a few studies included more than one physiological measure; further research considering how physiological measures relate to one another may be beneficial.

This review has highlighted that a range of psychosocial interventions have benefits for the emotional state of people with dementia, however more research that tries to establish the elements of change may help encourage personalisation of care. There are a broad range of factors that could be considered instrumental to change including interactions with facilitators, interactions with other group members, how much the activity aligns with their interests to name a few. Further research into how those factors affect outcomes in the research may support the case for person-centred care rather than a one size fits all approach that may account for the range of individual results in the studies included (Baillon et al., 2005; Raglio et al., 2010).

The research focusing on people in the later stages of dementia tends to use carers or facilitators observations as a measure of the persons experience. More detailed observations of participants in the later stages of dementia during an intervention whilst physiological measures are being monitored may be beneficial to help understand the relationship between their internal experience and the physiological responses. Video analysis (Clare et al., 2019) has been shown to be one way to achieve this depth of analysis as it would enable to look closely at each individual in a group setting and observe subtle changes in expressions or interactions and further development of this method is warranted.

Conclusions

This review has indicated that physiological responses may provide information on the emotional state of people with dementia during psychosocial interventions, however the multiplicity of interventions and outcomes and the early stages of development in this area make it difficult to draw firm conclusions. HR and HRV have shown the most consistent relationships to emotion state with heart rate decreasing and heart rate variability increasing following a range of psychosocial interventions with improvements in at least one measure of emotional state. Salivary CgA and cortisol also show promise as indicators of stress and mood, however the results are less consistent, and sampling has been found to be a challenging for researchers. Future research using video analysis to gather more detailed observations of an individual's experiences and larger scale studies with more rigorous methodology would be beneficial for developing the evidence base in this field.

References

Baillon, S., Van Diepen, E., Prettyman, R., Redman, J., Rooke, N., & Campbell, R. (2004). A comparison of the effects of Snoezelen and reminiscence therapy on the agitated behaviour of patients with dementia. *International Journal of Geriatric Psychiatry*, *19*(11), 1047-1052. https://doi.org/10.1002/gps.1208

Baillon, S., van Diepen, E., Prettyman, R., Rooke, N., Redman, J., & Campbell, R. (2005). Variability in response of older people with dementia to both Snoezelen and reminiscence. *British Journal of Occupational Therapy*, *68*(8), 367-374. https://doi.org/10.1177/030802260506800805

Bains, J., Birks, J., & Dening, T. (2002). Antidepressants for treating depression in dementia. *Cochrane Database of Systematic Reviews*, (4). https://doi.org/10.1002/14651858.CD003944

Baird, A., & Samson, S. (2015). Music and dementia. In *Progress in brain research* (Vol. 217, pp. 207-235). Elsevier. https://doi.org/10.1016/bs.pbr.2014.11.028

Baker, R., & Dowling, Z. (1995). Interact. *Research and Development Support Unit, Poole Hospital, Dorset*.

Baker, R., Holloway, J., Holtkamp, C. C., Larsson, A., Hartman, L. C., Pearce, R., Scherman, B., Johansson, S., Thomas, P., Wareing, L. & Owens, M. (2003). Effects of multi-sensory stimulation for people with dementia. *Journal of Advanced Nursing*, *43*(5), 465-477. https://doi.org/10.1046/j.1365-2648.2003.02744.x

Balestreri, L., Grossberg, A., & Grossberg, G. T. (2000). Behavioral and psychological symptoms of dementia as a risk factor for nursing home placement. International Psychogeriatrics, 12(S1), 59-62. https://doi.org/10.1017/S1041610200006773

Barrett, L. F., Lewis, M., & Haviland-Jones, J. M. (Eds.). (2016). *Handbook of emotions*. Guilford Publications.

Birkenhäger-Gillesse, E. G., Kollen, B. J., Achterberg, W. P., Boersma, F., Jongman, L., & Zuidema, S. U. (2018). Effects of psychosocial interventions for behavioral and psychological symptoms in dementia on the prescription of psychotropic drugs: a systematic review and meta-analyses. *Journal of the American Medical Directors Association*, *19*, 276-e1. https://doi.org/10.1016/j.jamda.2017.12.100

Bourne, P., Camic, P. M., Crutch, S., Hulbert, S., Firth, N., & Harding, E. (2019). Using psychological and physiological measures in arts-based activities in a community sample of people with a dementia and their caregivers: a feasibility and pilot study. *Journal of Aging Studies and Therapies*, *1*(1). Retrieved from: https://sciforschenonline.org/journals/aging-studies-therapies/article-data/JAST102/JAST102.pdf

Camic, P. M., Baker, E. L., & Tischler, V. (2016). Theorizing how art gallery interventions impact people with dementia and their caregivers. *The Gerontologist*, *56*(6), 1033-1041. https://doi.org/10.1093/geront/gnv063

Cammisuli, D. M., Danti, S., Bosinelli, F., & Cipriani, G. (2016). Non-pharmacological interventions for people with Alzheimer's disease: a critical review of the scientific literature from the last ten years. *European Geriatric Medicine*, *7*(1), 57-64. https://doi.org/10.1016/j.eurger.2016.01.002

Canevelli, M., Adali, N., Cantet, C., Andrieu, S., Bruno, G., Cesari, M., & Vellas, B. (2013). Impact of behavioral subsyndromes on cognitive decline in Alzheimer’s disease: data from the ICTUS study. *Journal of Neurology*, *260*(7), 1859-1865. https://doi.org/10.1007/s00415-013-6893-3

Chan, M. F., Chan, E. A., & Mok, E. (2010). Effects of music on depression and sleep quality in elderly people: A randomised controlled trial. *Complementary Therapies in Medicine*, *18*(3-4), 150-159. https://doi.org/10.1016/j.ctim.2010.02.004

Chu, H., Yang, C. Y., Lin, Y., Ou, K. L., Lee, T. Y., O'Brien, A. P., & Chou, K. R. (2014). The impact of group music therapy on depression and cognition in elderly persons with dementia: a randomized controlled study. *Biological research for Nursing*, *16*(2), 209-217. https://doi.org/10.1177/1099800413485410

Chung, J. C., & Lai, C. K. (2002). Snoezelen for dementia. *Cochrane Database of Systematic Reviews*, (4). https://doi.org/10.1002/14651858.CD003152

Clare, A., & Camic, P. M. (2019). Live and recorded group music interventions with active participation for people with dementias: a systematic review. *Arts & Health*, 1-24. https://doi.org/10.1080/17533015.2019.1675732

Cooper, C., Mukadam, N., Katona, C., Lyketsos, C. G., Ames, D., Rabins, P., Engedal, K., Lima, C., Blazer, D., Teri, L., Brodaty, H., & Livingston, G. (2012). Systematic review of the effectiveness of non-pharmacological interventions to improve quality of life of people with dementia. *International Psychogeriatrics*, *24*, 856-870. https://doi.org/10.1017/S1041610211002614

Cousins, E., Tischler, V., Garabedian, C., & Dening, T. (2020). A taxonomy of arts interventions for people with dementia. *The Gerontologist*, *60*, 124-134. https://doi.org/10.1080/17533015.2018.1490787

Cruess, D. G., Antoni, M. H., Kumar, M., & Schneiderman, N. (2000). Reductions in salivary cortisol are associated with mood improvement during relaxation training among

HIV-seropositive men. *Journal of Behavioral Medicine*, *23*(2), 107-122. https://doi.org/10.1023/A:1005419917023

Cuddy, L. L., & Duffin, J. (2005). Music, memory, and Alzheimer's disease: is music recognition spared in dementia, and how can it be assessed?. *Medical Hypotheses*, *64*(2), 229-235. https://doi.org/10.1016/j.mehy.2004.09.005

Cummings, J. L., Mega, M., Gray, K., Rosenberg-Thompson, S., Carusi, D. A., & Gornbein, J. (1994). The Neuropsychiatric Inventory: comprehensive assessment of psychopathology in dementia. *Neurology*, *44*(12), 2308-2308. https://doi.org/10.1212/WNL.44.12.2308

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

D'Cunha, N. M., McKune, A. J., Isbel, S., Kellett, J., Georgousopoulou, E. N., & Naumovski, N. (2019). Psychophysiological responses in people living with dementia after an art gallery intervention: An exploratory study. *Journal of Alzheimer's Disease*, 1-14. https://doi.org/10.3233/JAD-190784

Department of Health. (2009). *Living well with dementia: A national dementia strategy.* Retrieved from: https://www.gov.uk/government/publications/living-well-with-dementia-a-national-dementia-strategy

Feast, A., Moniz-Cook, E., Stoner, C., Charlesworth, G., & Orrell, M. (2016). A systematic review of the relationship between behavioral and psychological symptoms (BPSD) and caregiver wellbeing. *International Psychogeriatrics*, *28*(11), 1761-1774. https://doi.org/10.1017/S1041610216000922

Gerdner, L. (1997). An individualized music intervention for agitation. *Journal of the American Psychiatric Nurses Association*, *3*(6), 177-184. https://doi.org/10.1177/107839039700300603

Gómez-Romero, M., Jiménez-Palomares, M., Rodríguez-Mansilla, J., Flores-Nieto, A., Garrido-Ardila, E. M., & González-López-Arza, M. V. (2017). Benefits of music therapy on behaviour disorders in subjects diagnosed with dementia: A systematic review. *Neurología (English Edition)*, *32*(4), 253-263. https://doi.org/10.1016/j.nrleng.2014.11.003

Guidi, J., Brakemeier, E. L., Bockting, C. L., Cosci, F., Cuijpers, P., Jarrett, R. B., Linden, M., Marks, I., Peretti, C., Rafanelli, C., Rief, W., Schneider, S., Schnyder, U., Sensky, T., Tomba, E., Vazquez, C., Vieta, E., Zipfel, S., Wright, J., & Fava, G. (2018). Methodological recommendations for trials of psychological interventions. *Psychotherapy and psychosomatics*, *87*(5), 276-284. https://doi.org/10.1159/000490574

Helmes, E., Csapo, K. G., & Short, J. A. (1987). Standardization and validation of the multidimensional observation scale for elderly subjects (MOSES). *Journal of Gerontology*, *42*(4), 395-405. https://doi.org/10.1093/geronj/42.4.395

Heyn, P. (2003). The effect of a multisensory exercise program on engagement, behavior, and selected physiological indexes in persons with dementia. *American Journal of Alzheimer's Disease & Other Dementias®*, *18*(4), 247-251. https://doi.org/10.1177/153331750301800409

Homma, A., Niina, R., Ishii, T., & Hasegawa, K. (1991). Behavioral evaluation of Alzheimer disease in clinical trials: Development of the Japanese version of the GBS Scale. *Alzheimer Disease & Associated Disorders*, *5*, S40-S48.

Hsu, M. H., Flowerdew, R., Parker, M., Fachner, J., & Odell-Miller, H. (2015). Individual music therapy for managing neuropsychiatric symptoms for people with dementia and their carers: a cluster randomised controlled feasibility study. *BMC Geriatrics*, *15*(1), 84. https://doi.org/10.1186/s12877-015-0082-4

Kaimal, G., Ray, K., & Muniz, J. (2016). Reduction of cortisol levels and participants' responses following art making. *Art Therapy*, *33*(2), 74-80. https://doi.org/10.1080/07421656.2016.1166832

Kales, H. C., Gitlin, L. N., & Lyketsos, C. G. (2015). Assessment and management of behavioral and psychological symptoms of dementia. *BMJ*, *350*, h369. https://doi.org/10.1136/bmj.h369

Kitwood, T. (1990). Psychotherapy and dementia. *Psychotherapy Section Newsletter*, *8*, 40-56.

Kitwood, T. (1998). Toward a theory of dementia care: ethics and interaction. *J Clin Ethics,* *9*(1), 23-34.

Koger, S. M., Chapin, K., & Brotons, M. (1999). Is music therapy an effective intervention for dementia? A meta-analytic review of literature. *Journal of Music Therapy*, *36*(1), 2-15. https://doi.org/10.1093/jmt/36.1.2

Koopmans, R. T., van der Molen, M., Raats, M., & Ettema, T. P. (2009). Neuropsychiatric symptoms and quality of life in patients in the final phase of dementia. *International*

Journal of Geriatric Psychiatry: A Journal of the Psychiatry of Late Life and Allied Sciences, *24*, 25-32. https://doi.org/10.1002/gps.2040

Kratz, T. (2017). The diagnosis and treatment of behavioral disorders in dementia. *Deutsches Ärzteblatt International*, *114*, 447. https://doi.org.10.3238/arztebl.2017.0447

Kim, H. G., Cheon, E. J., Bai, D. S., Lee, Y. H., & Koo, B. H. (2018). Stress and heart rate variability: A meta-analysis and review of the literature. *Psychiatry Investigation*, *15*(3), 235. https://doi.org/10.30773/pi.2017.08.17

Lawrence, V., Fossey, J., Ballard, C., Moniz-Cook, E., & Murray, J. (2012). Improving quality of life for people with dementia in care homes: making psychosocial interventions work. *The British Journal of Psychiatry*, *201*(5), 344-351. https://doi.org/10.1192/bjp.bp.111.101402

Lindenmuth, G. F., Patel, M., & Chang, P. K. (1992). Effects of music on sleep in healthy elderly and subjects with senile dementia of the Alzheimer type. *American Journal of Alzheimer's Care and Related Disorders & Research*, *7*(2), 13-20. https://doi.org/10.1177/153331759200700204

Livingston, G., Kelly, L., Lewis-Holmes, E., Baio, G., Morris, S., Patel, N., Omar, R., Katona, C. & Cooper, C. (2014). Non-pharmacological interventions for agitation in dementia: systematic review of randomised controlled trials. *The British Journal of Psychiatry*, *205*(6), 436-442. https://doi.org/10.1192/bjp.bp.113.141119

López-Almela, A., & Gómez-Conesa, A. (2011). Intervención en demencias mediante estimulación multisensorial (snoezelen). *Fisioterapia*, *33*, 79-88. https://doi.org/10.1016/j.ft.2011.02.004

Mukadam, N., Cooper, C., & Livingston, G. (2013). Improving access to dementia services for people from minority ethnic groups. *Current Opinion in Psychiatry*, *26*(4), 409. https://doi.org/ 10.1097/YCO.0b013e32835ee668

Maseda, A., Cibeira, N., Lorenzo-López, L., González-Abraldes, I., Buján, A., de Labra, C., & Millán-Calenti, J. C. (2018). Multisensory stimulation and individualized music sessions on older adults with severe dementia: effects on mood, behavior, and biomedical parameters. *Journal of Alzheimer's Disease*, *63*(4), 1415-1425.

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion*, *23*(2), 209-237. https://doi.org/10.1080/02699930802204677

McDermott, O., Crellin, N., Ridder, H. M., & Orrell, M. (2013). Music therapy in dementia: a narrative synthesis systematic review. *International journal of geriatric psychiatry*, *28*(8), 781-794. https://doi.org/10.1002/gps.3895

McDermott, O., Charlesworth, G., Hogervorst, E., Stoner, C., Moniz-Cook, E., Spector, A., Cspike, E., & Orrell, M. (2019). Psychosocial interventions for people with dementia: a synthesis of systematic reviews. *Aging & Mental Health*, *23*, 393-403. https://doi.org/10.1080/13607863.2017.1423031

McKinney, C. H., Antoni, M. H., Kumar, M., Tims, F. C., & McCabe, P. M. (1997). Effects of guided imagery and music (GIM) therapy on mood and cortisol in healthy adults. *Health Psychology*, *16*(4), 390. https://doi.org/10.1037/0278-6133.16.4.390

Miluk-Kolasa, B., Obminski, Z., Stupnicki, R., & Golec, L. (1994). Effects of music treatment on salivary cortisol in patients exposed to pre-surgical stress. *Experimental and Clinical Endocrinology & Diabetes*, *102*(02), 118-120. https://doi.org/10.1055/s-0029-1211273

Nakane, H., Asami, O., Yamada, Y., Harada, T., Matsui, N., Kanno, T., & Yanaihara, N. (1998). Salivary chromogranin A as an index of psychosomatic stress response. *Biomedical Research*, *19*(6), 401-406 https://doi.org/10.2220/biomedres.19.401

Nolan, M. R., Davies, S., Brown, J., Keady, J., & Nolan, J. (2004). Beyond 'person-centred'care: a new vision for gerontological nursing. *Journal of Clinical Nursing*, *13*, 45-53. https://doi.org/10.1111/j.1365-2702.2004.00926.x

Noone, D., Stott, J., Aguirre, E., Llanfear, K., & Spector, A. (2019). Meta-analysis of psychosocial interventions for people with dementia and anxiety or depression. *Aging & Mental Health*, *23*, 1282-1291. https://doi.org/10.1080/13607863.2018.1495177

Norberg, A., Melin, E., & Asplund, K. (2003). Reactions to music, touch and object presentation in the final stage of dementia: an exploratory study. *International Journal of Nursing Studies*, *40*(5), 473-479. https://doi.org/10.1016/S0020-7489(03)00062-2

Office of national statistics (2018). Dementia diagnosis.

Patel, B., Perera, M., Pendleton, J., Richman, A., & Majumdar, B. (2014). Psychosocial interventions for dementia: from evidence to practice. *Advances in Psychiatric Treatment*, *20*, 340-349. https://doi.org/10.1192/apt.bp.113.011957

Pedersen, S. K., Andersen, P. N., Lugo, R. G., Andreassen, M., & Sütterlin, S. (2017). Effects of music on agitation in dementia: a meta-analysis. *Frontiers in Psychology*, *8*, 742. https://doi.org/10.3389/fpsyg.2017.00742

Pedrinolla, A., Tamburin, S., Brasioli, A., Sollima, A., Fonte, C., Muti, E., Smania, N., Schena, F. & Venturelli, M. (2019). An indoor therapeutic garden for behavioral symptoms in Alzheimer’s aisease: A randomized controlled trial. *Journal of Alzheimer's Disease*, *71*(3), 813-823. https://doi.org/10.3233/JAD-190394

Raglio, A., Oasi, O., Gianotti, M., Manzoni, V., Bolis, S., C Ubezio, M., Gentile, S., Villani, D. & Stramba-Badiale, M. (2010). Effects of music therapy on psychological symptoms and heart rate variability in patients with dementia. A pilot study. *Current Aging Science*, *3*(3), 242-246. https://doi.org/10.2174/1874609811003030242

Reisberg, B., Borenstein, J., Salob, S. P., Ferris, S. H., Franssen, E., & Georgotas, A. (1987). Behavioural pathology in Alzheimer's Disease Rating Scale. *J Clin Psych*, *48*(5), 9-15.

Ridder, H. M., Wigram, T., & Ottesen, A. M. (2009). A pilot study on the effects of music therapy on frontotemporal dementia–developing a research protocol. *Nordic Journal of Music Therapy*, *18*(2), 103-132. https://doi.org/10.1080/08098130903062371

Sánchez, A., Maseda, A., Marante-Moar, M. P., de Labra, C., Lorenzo-López, L., & Millán-Calenti, J. C. (2016). Comparing the effects of multisensory stimulation and individualized music sessions on elderly people with severe dementia: A randomized controlled trial. *Journal of Alzheimer's Disease*, *52*(1), 303-315. https://doi.org/10.3233/JAD-151150

Sakamoto, M., Ando, H., & Tsutou, A. (2013). Comparing the effects of different individualized music interventions for elderly individuals with severe dementia. *International Psychogeriatrics*, *25*(5), 775-784. https://doi.org/10.1017/S1041610212002256

Shapiro, M., Parush, S., Green, M., & Roth, D. (1997). The efficacy of the “Snoezelen” in the management of children with mental retardation who exhibit maladaptive behaviours.

The British Journal of Development Disabilities, *43*(85), 140-155. https://doi.org/10.1179/bjdd.1997.014

Smith, M., Gerdner, L. A., Hall, G. R., & Buckwalter, K. C. (2004). History, development, and future of the progressively lowered stress threshold: a conceptual model for dementia care. *Journal of the American Geriatrics Society*, *52*(10), 1755-1760. https://doi.org/10.1111/j.1532-5415.2004.52473.x

Suzuki, M., Kanamori, M., Watanabe, M., Nagasawa, S., Kojima, E., Ooshiro, H., & Nakahara, D. (2004). Behavioral and endocrinological evaluation of music therapy for elderly patients with dementia. *Nursing & Health Sciences*, *6*(1), 11-18. https://doi.org/10.1111/j.1442-2018.2003.00168.x

Suzuki, M., Kanamori, M., Nagasawa, S., Tokiko, I., & Takayuki, S. (2007). Music therapy-induced changes in behavioral evaluations, and saliva chromogranin A and immunoglobulin A concentrations in elderly patients with senile dementia. *Geriatrics & Gerontology International*, *7*(1), 61-71. https://doi.org/10.1111/j.1447-0594.2007.00374.x

Svansdottir, H. B., & Snaedal, J. (2006). Music therapy in moderate and severe dementia of Alzheimer's type: a case–control study. *International Psychogeriatrics*, *18*(4), 613-621. https://doi.org/ https://doi.org/10.1017/S1041610206003206

Tariot, P. N. (2003). Medical management of advanced dementia. *Journal of the American Geriatrics Society, 51*(5s2), S305-S313. https://doi.org/10.1046/j.1532-5415.5156.x

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

Thomas, G. E., Crutch, S. J., Camic, P. M. (2018). Measuring physiological responses to the arts in people with a dementia. *International Journal of Psychophysiology,* 123, 64-73. https://doi.org/10.1016/j.ijpsycho.2017.11.008

Valdiglesias, V., Maseda, A., Lorenzo-López, L., Pásaro, E., Millán-Calenti, J. C., & Laffon, B. (2017). Is salivary chromogranin A a valid psychological stress biomarker during sensory stimulation in people with advanced dementia?. *Journal of Alzheimer's Disease, 55*(4), 1509-1517. https://doi.org/ 10.3233/JAD-160893

Van Eck, M., Berkhof, H., Nicolson, N., & Sulon, J. (1996). The effects of perceived stress, traits, mood states, and stressful daily events on salivary cortisol. *Psychosomatic Medicine*, *58*(5), 447-458. http://dx.doi.org/10.1097/00006842-199609000-00007

Venturelli, M., Sollima, A., Cè, E., Limonta, E., Bisconti, A. V., Brasioli, A., Muti, E., & Esposito, F. (2016). Effectiveness of exercise-and cognitive-based treatments on salivary cortisol levels and sundowning syndrome symptoms in patients with Alzheimer's disease. *Journal of Alzheimer's Disease, 53*(4), 1631-1640. https://doi.org/ 10.3233/JAD-160392

Vink, A. C., Bruinsma, M. S., & Scholten, R. J. S. (2011). *Music therapy for people with dementia (updated Cochrane Review).* The Cochrane Library. Chichester: Wiley.

Vink, A., & Hanser, S. (2018). Music-based therapeutic interventions for people with dementia: A mini-review. *Medicines, 5*(4), 109. https://doi.org/10.3390/medicines5040109

Wilhelm, F. H., Pfaltz, M. C., Grossman, P., & Roth, W. T. (2006). Distinguishing emotional from physical activation in ambulatory psychophysiological monitoring. *Biomedical Sciences Instrumentation*, *42*, 458-463.

Williams, C., Tappen, R., Wiese, L., Newman, D., Corbett, M., Pinos, S., Curtis, B., & Murray, B. (2016). Stress in persons with dementia: Benefits of a memory center day program. *Archives of Psychiatric Nursing*, *30*(5), 531-538. https://doi.org/10.1016/j.apnu.2016.04.011

World Health Organization. (2019). Risk reduction of cognitive decline and dementia: WHO guidelines. In *Risk reduction of cognitive decline and dementia: WHO guidelines*, 401-401. Geneva: WHO.

Section B

Singing and music making: Physiological responses of people in early and later stages of dementia

Word count: 7997 (497)

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Abstract

Music based interventions have been found to improve the wellbeing of people with dementia. Physiological responses can provide more information about the individual's experience of an activity and may be particularly useful for individuals who are experiencing difficulties with communication. This multiple-case study design drew on previously collected, unanalysed archival data and explored the physiological responses of 9 people with mild-to-moderate dementia during a singing group and 6 people in the later stages of dementia during an interactive music group. Medical grade wearable wristbands provided information on heart rate (HR), electrodermal activity (EDA), movement (ACC) and skin temperature (ST). The interactive music group was video recorded in order to provide additional context.

Physiological responses of each participant were analysed using simulation modelling analysis within individual case studies. Participants in the singing group showed an increase in EDA and HR as the session began. HR and ST increased during faster paced songs. EDA, movement and engagement were all higher during an interactive music group than during the control session. EDA and ST increased and in contrast to the responses during singing, HR decreased as the sessions began. EDA was higher during slower music, however this was less consistent in the more interactive intervention sessions than the control. There were no consistent changes in HR and ACC responses during different styles of music. Physiological responses peaked during familiar music, interactions, physical touch in addition to times that participants appeared disengaged.

Physiological responses may provide valuable information about the experiences of an intervention for people with dementia, however they should be used in conjunction with other measures to develop a more nuanced understanding. Future research should consider

using physiological measures with video-analysis and psychometric measures to explore further how engagement, wellbeing and physiology interact.

Keywords: Dementia, Physiological, Psychosocial, Music, Singing, Wellbeing

Introduction

There are an estimated 850,000 people in the UK currently living with dementia, expecting to rise to 1.6 million by 2040 (Wittenberg et al., 2019). Symptoms of dementia vary for each individual and type of dementia, affecting memory, thinking, behaviour and the ability to perform everyday tasks (WHO, 2019). There is currently no pharmaceutical cure for any sub-type of dementia. The National Institute for Health Care Excellence (NICE) has stated that medication only offers small cognitive, functional and behavioural benefits for people with mild-to-moderate dementia (NICE, 2019). Neuroleptic medications are often prescribed to manage the behavioural, psychological and social symptoms of dementia (BPSD) with some positive outcomes (Kratz, 2017), yet these medications often have side effects and the evidence for the efficacy is mixed (Cooper et al., 2012). Finding psychosocial interventions to improve the quality of life of people with dementia (PWD) and their carers is therefore warranted.

Theories of wellbeing in dementia

Although historically, the primary focus of dementia care has been attending to physical care needs, there have been significant shifts towards considering the individual's higher order needs, highlighted by the theory of "personhood" (Kitwood, 1997). Personhood emphasises comfort, attachment, inclusion, occupation and identity as integral to wellbeing. Kitwood notes that care environments that do not foster these needs lead to a state of "illbeing" for the person with dementia. In recent years more consideration has been given to the wellbeing of the individual in the context of their relationships. Relational theories of dementia offer the opportunity to encapsulate the reciprocity and interdependence of caring relationships (Clare et al., 2020) and how these relate to the wellbeing of an individual. Nolan et al., (2004) proposed the "senses framework" which suggests that all parties involved in caring need to promote a sense of security, belonging, continuity, purpose, achievement and significance. These theoretical shifts in conjunction with the lack of pharmaceutical treatment have created an increased emphasis on the importance of psychosocial interventions to improve the wellbeing of PWD.

Psychosocial interventions and wellbeing

Psychosocial interventions incorporate a broad range of activities which share a common aim of improving the quality of life. Effective interventions have been found to improve wellbeing in several ways. These include enabling the individual to maintain self-esteem and belonging (Brod et al., 1999). As with more traditional one-to-one therapy, both the content and the process may play a role in the intervention. Aside from the stimulation of the activity itself, other important factors may include interactions with others, physical movement and/or individual meaning of the activity (Clare et al., 2019).

Maintaining relationships with people with a dementia diagnosis can feel challenging in the later stages. Interactions often become task-oriented due to the caregiver feeling solely responsible for initiating social interactions (Penrod et al., 2007). Paid carers may start to focus more on basic care needs when a PWD is less able to respond during interactions (Edvardsson et al., 2014), particularly when they have not been trained to provide stimulating activities (Mowrey et al., 2013).

Incorporating the aforementioned theories of wellbeing into the design and implementation of psychosocial interventions may be beneficial. For example, the fostering of “personhood” (Kitwood, 1997) within an intervention may be achieved by ensuring the activity is personally meaningful and inclusive. Camic et al. (2013) proposed that the Nolan’s five senses framework (Nolan et al., 2004) could be utilised as a way of theoretically understanding and evaluating psychosocial interventions for PWD. Observing interactions within a group intervention that relate to security, belonging, continuity, purpose, achievement and significance may therefore provide information on how beneficial and intervention is for the person's wellbeing.

Musical interventions for people with dementia

The ability to recall and respond to music is often retained for longer than other information (Cuddy & Duffin, 2005) and benefits related to cognition and wellbeing are well documented (e.g. Gallego & Garcia 2017; Särkämö, 2018). Music-based activities have also been reported to reduce aggressive behaviour (Clark et al., 1998), stimulate communication (Clare et al., 2020) and are cost effective when compared to medication and increased levels of care (Livingston et al., 2014). A review by Van der Steen et al. (2017) however, concluded that quality of evidence is low and although music-based activities may improve depression, they have little or no impact on agitation or emotional wellbeing.

Stress, emotion and physiological responses

The relationship between an individual's emotional state and physiological responses is complex. The autonomic nervous system (ANS), which is made up of the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS) has a direct role in stress response with the SNS activating and creating the "fight or flight response". Stress can therefore often be detected using physiological parameters that are influenced by SNS such as increased heart rate (HR) and electrodermal activity (EDA) (Wijsman et al., 2011). The ANS has been considered as integral to the emotional response of healthy individuals and linked to specific emotions (Kreibig 2010). Stemmler (2004) reported on a meta-analysis of autonomic responding in anger and fear and found considerable differences between the two, despite similar arousal characteristics. In contrast Barrett (2014) claimed that it is not possible to claim that emotion has "unique autonomic signatures" (p.41).

Wellbeing and physiological responses during musical interventions

It is widely accepted that music has the capacity to alter emotions and research has shown healthy adults effectively using music to regulate how they are feeling (Chen et al., 2007; Getz et al., 2014). Listening to music has been associated with arousal including increased EDA, HR and respiration rate (Gomez & Danuser, 2004; Salimpoor et al., 2009). It has also been found to lower arousal in the presence of stressors (Thoma et al., 2013). Faster tempo, staccato music is more likely to induce arousal including increased blood pressure, HR and skin conductance (Bernardi et al., 2006; Gomez and Danuser, 2007). Other factors including listening to music with a friend or self-selecting music have been suggested to increase positive emotional responses (Liljestrom et al., 2013).

There is emerging research measuring physiological responses in PWD during psychosocial interventions (Hsu, 2015; Suzuki et al., 2007; Williams et al., 2016). A review by Thomas et al. (2018) concluded that research concerning physiological interventions and music is limited, but studies measuring HR and heart rate variability (HRV) showed statistically significant changes within sessions. However, Raglio et al. (2010) found no significant longitudinal changes in HR over a music therapy intervention, suggesting the benefits may be limited to brief moments in time. Interpreting HR is not straightforward as it is impacted by a range of factors including movement, anxiety and excitement (Wilhelm et al., 2006), therefore measuring in conjunction with other information such as observations may be beneficial.

EDA is commonly used as a measure of arousal as it is considered a reliable marker of sympathetic activity (Andreassi, 2007). An increase in EDA has been suggested to indicate agitation in PWD as increases have been found to occur just before agitation can be visually observed (Melander et al., 2017). A review of the ANS activity in emotion linked increased EDA to fear and disgust but also to happiness and anticipatory pleasure in healthy adults suggesting it is difficult to make conclusions based on the physiology alone (Kreibig, 2010).

Acute stress has been associated with a short-term drop in skin temperature related to an increase in core temperature (Oka et al., 2001) and has therefore been suggested as a valuable non-invasive way of quantifying stress (Herborn et al., 2015). To date, no research has been identified observing changes in ST during music-based interventions for PWD. There is also a shortage of research on physiological responses in the later stages of dementia; this research may be particularly valuable for individuals that may be less able to communicate their experiences verbally and may not appear engaged to observers.

Rationale

The above research has outlined emerging evidence that physiological measures may be a helpful tool for understanding the experiences of PWD during psychosocial interventions. Using individual case studies to take a more detailed look at individual experiences within smaller sections of an intervention may enable a richer understanding of what happens physiologically during musical interventions and how different responses relate to each other. Kitwood's (1997) theory of personhood and the senses framework by Nolan et al., (2004) suggest that the beneficial aspects of an intervention may be in the sense of inclusion, achievement and purpose which could depend on interpersonal factors aside from the type of intervention. There is no research to date considering how physiological responses relate to recorded observations during psychosocial interventions for PWD. Observing how physiological responses relate to engagement and individual interactions may be a beneficial was of understanding more about the experiences of a person with dementia during a psychosocial intervention.

Aims of the study

This research consists of two linked studies using archival data from two music-based interventions for people at two different stages of dementia. These studies aimed to gain a better understanding of what physiological responses of PWD might convey about their experiences, and how they may relate to wellbeing. This research addresses NHS values including "compassion" and "commitment to quality of care" as the activities are designed to alleviate distress and improve wellbeing for people with a dementia. Trying to understand and improve the activities for people in the later stages of dementia also fits with the value of "everybody counts". Specific hypotheses have been formulated based on previous research (Bourne et al. 2017;; Gomez & Danuser, 2007; Thomas et al. 2018).

Study 1 and Study 2 Hypotheses

Study 1

H1: Physiological responses will be significantly higher during the first song compared to baseline

H2: Physiological responses will differ during fast and slow music

Study 2

H3: Physiological responses will be significantly higher during the intervention sessions (sessions 1 and 6) compared to the control session.

H4: There will be no significant difference between the physiological responses in the intervention sessions (session 1 and 6)

H5: Physiological responses will be significantly higher during the first song compared to baseline

H6: Physiological responses will differ during different types of music

H7: Changes in physiological responses will be associated with ratings of engagement and visible engagement from observations

H8: Peaks in physiological data will be associated with visible engagement

Method

This research consists of two linked mixed-methods multiple-case A-B design studies based on archival data from naturalistic settings (Yin, 2003). Barlow et al., (2009) suggests that replication can be established with a minimum of four case studies and the design enables a more sensitive detection of change than group averages. Study 1 includes nine case studies of the physiological responses of people with mild-to-moderate dementia during one session of a community singing group. Study 2 included six more detailed case studies, collating information on participants who had attended a control session and two intervention sessions of an interactive music group. These participants were in the later stages of dementia, living in a residential care home. The data were collected by a research team in late 2017 and has not previously been analysed.

Materials used in both studies

Empatica-E4 sensor wristbands were worn by all participants in study 1 and 2 (Appendix C) and measured HR, EDA, movement (ACC) and ST. The sensors produced a per second numeric output related to each physiological measure. EDA and ST produced four readings per second (4Hz), HR one reading (1Hz) and ACC 32 readings (32Hz). Audio recordings were made of both groups in order to compare physiological measures to the activity.

Ethical procedures for both studies

Ethical procedures are reported below. During or after the sessions, no reports of discomfort or desire to remove the wrist bands were voiced nor did anyone choose to withdraw from the study. Data were encrypted and stored anonymously using participant ID numbers and saved on a password protected hard drive. All data were stored in accordance with the Data Protection Act (2018). Following the interactive music sessions, video data were downloaded onto an encrypted and password protected file by the consultant for the project. Video data were only viewed using an encrypted hard drive and the data were downloaded on to a password protected computer in a non-public location.

Ethical Procedures for Study 1 and Study 2

Both studies

Consent was considered for each individual in line with the mental capacity act (MCA, Department of Health, 2005) by two researchers (one a senior clinician).

Study 1

All participants were deemed to have capacity to consent. Participants were informed about the research through a question and answer session, given a participant information sheet to consider for a week beforehand, provided time for individual discussion the following week, and only then was informed consent was taken.

Study 2

In study 2, none of the participants were deemed able to give consent due to being in the advanced stages of dementia. Family members who were legal guardians were therefore invited to a group information meeting at the care home, provided written participant information and given one week to consider whether to participate, which they all agreed to. Family members were asked to sign a form stating "If my relative had been able to give consent for this I believe they would have agreed to participate and think this is something they would have wanted." Musicians and staff members also signed consent forms to feature in the video and audio recordings of the sessions (Appendix D).

Study 1

Participants

Participants were recruited from an existing singing group for PWD and their carers (Table 1). All group members were invited to take part and inclusion criteria were purposely kept broad: a diagnosis of mild-to-moderate dementia and ability to give informed consent.

Table 1

Demographics of Study 1 Participants

Par number	Diagnosis	Age	Gender	Ethnicity
1	AD	75-80	M	White British
2	Mixed AD/FTD	75-80	M	White British
3	AD	80-85	M	White British
4	AD	70-75	F	White European
5	AD	> 85	F	White European
6	DLB	65-70	M	White British
7	AD	75-80	M	White British
8	FTD	65-70	M	White European
9	AD	> 85	F	White British

AD = Alzheimer's disease, FTD = Frontotemporal dementia, DLB = Dementia with Lewy bodies

Procedure

Empatica-E4 were fitted to participants' wrists on their dominant hands. The session ran for approximately 1 hour and was led by an experienced choral conductor with an accompanying pianist. It consisted of a welcome song, stretching and vocal exercises, followed by four songs (Bella Mama, Bei Mannern, In the Jungle and Erie Canal) broken down and practiced and then sung in their entirety. Participants were intermittently asked to stand and sit down. The style of songs ranged from a legato slower paced style to a quicker staccato style. Two songs were used for comparison (Table 2). Following the session, participants returned to their tables for refreshments and removal of their wrist bands.

Table 2

Musical Styles for Comparison

	Style	Description
Bei Mannern (Slower)	Classical	Major key, crescendo and diminuendo, Adante (walking pace)
Eerie Canal (Faster)	Show tune	Major key, Forte (loud), Energetic

The group had been running for approximately two months. The participants were therefore comfortable with the environment and group, reducing the likelihood of confounding variables such as anxiety about socializing and having an unknown facilitator thus increasing the validity of the data. Although there was no control group, data before the singing began was used as a baseline.

Data analysis

All participants were included in the analysis. Audio recordings were matched to the timestamped pre-collected physiological measures to determine the time in the session. Data sets were then collated for all timeframes and physiological measures for each individual case study (Table 3). Physiological responses were chunked into ten second intervals and then analysed using Simulation Modelling Analysis (SMA) which enables case-based time-series studies with multiple observations to determine individual change (Borckardt et al., 2008). Non-parametric tests (Spearman's Rho) were administered due to the small sample size. Bonferroni corrections were used to control for multiple comparisons by dividing significance of 0.05 by the number of tests administered (72).

Table 3

Data Selection in Study 1

Data sets		Length of data set
1	Pre music beginning	2m
2	First song of session	2m 25s
3	After first song	1m 44s
4	Energetic (fast) music	3m 22s
5	Adante (slow) music	2m 45s

Study 2

The case studies in study 1 provided useful information about physiological responses during a singing group and how musical style might play a role in wellbeing during mild-to-moderate stages. These data were interpreted with the knowledge that the group was popular and voluntarily attended, however this raised questions around how physiological responses might differ in the later stages of dementia and how these could be interpreted in a population that is not able to give consent to an intervention or verbally communicate their experiences.

Participants

Six participants who attended all three of the sessions of the interactive music group were included in the analysis (Table 4).

Table 4

Demographics of Study 2 Participants

Participant	Diagnosis	Age	Gender	Ethnicity
1	Atypical/mixed	97	Female	White British
2	AD	93	Female	White British
3	Mixed AD/VaD	92	Male	White British
4	AD	92	Male	White British
5	AD	85	Male	White British
6	VaD	88	Female	White British

AD = Alzheimer's disease, VaD = Vascular dementia

Procedure

The interactive music group by Music 4 Life[2] ran for eight hour-long sessions at the same time every week. A week prior to the group starting, a control session took place in the same room and time of day. The control involved listening to recorded music of a similar style to that in the intervention. Participants were asked to wear the Empatica-E4 wristbands during the control session, the first session and session six.

The intervention sessions consisted of three main pieces of music with additional improvised music in between. Musical styles ranged from slower tempo quieter music to upbeat staccato forte music. Instruments included a harp, flute, bongo drums and a range of handheld percussion instruments that participants were encouraged to use by staff and facilitators.

Materials

In addition to audio recording, a Fly 360-degree camera™ filmed the group in order to capture interactive components and processes for each individual clearly. The Video Coding – Incorporating Observed Emotion (VC-IOE) scale (Appendix E) was used to

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[2] https://www.musicforlife.org.uk/

monitor engagement from the video footage. This measure was chosen as it is designed specifically for video analysis (Jones et al., 2015) and provides information about the nature of the engagement (positive or negative) in addition to absence or presence. Inter-rater reliability has been found to be exceptionally high across ten different video coders (95.25%) when comparing within a 1 second tolerance interval. An optimal inter-rater reliability of 95% has also been obtained across dependent measures.

Data analysis

Datasets relating to each of the pre-determined measures of interest were collated and analysed (Table 5).

Table 5

Data Selection in Study 2

Measure	Session	Data analysis	Length of data set
1	Control	Pre music beginning	2m
2	Control	First piece of music	5m 9s
3	Control	Welcome song comparison	5m 23s
4	Control	Whole session	55m 46s
5	Control	Fast music	3m 45s
6	Control	Slow music	4m 12s
7	Session 1	Pre music beginning	2m
8	Session 1	First piece of music	5m 33s
9	Session 1	Welcome song	5m 20s
10	Session 1	Whole session	62m 11s
11	Session 1	Fast music	5m 35s
12	Session 1	Slow music	3m 35s
13	Session 6	Pre music beginning	2m
14	Session 6	First piece of music	5m 21s
15	Session 6	Welcome song	8m 17s
16	Session 6	Whole session	58m 16s
17	Session 6	Fast music	3m 34s
18	Session 6	Slow music	4m 15s

Emulating study 1, physiological responses were chunked into ten second intervals and then analysed using SMA as time-series data. In order to determine how the participants' presentation related to the physiological measures, engagement during fast and slow music was rated for three participants in three sessions using the VC-10E. This involved rating the number of seconds that categories of positive and negative engagement were present (Appendix F). Participants were selected that were visibly different in their level of engagement and to include male and female participants. Engagement was rated once by an independent clinician who was not aware of the research hypothesis. Points of increased physiological activity were also identified by sorting the physiological measures from greatest to smallest. The time periods with increased physiological activity were then observed in the video to record individual activity and context. This was only possible to undertake for HR, EDA and ST due to the number of readings per second.

Results

Study 1

Study 1 consists of 9 individual case studies of people in early-to-middle-stage dementia where physiological data were collected throughout the same singing session. Hypothesis 1 (H1) states that physiological measures will be significantly higher during the first song than during baseline and Hypothesis 2 (H2) states that physiological responses will differ during different styles of music. These will be addressed in turn. Each case study includes a table of the mean average and standard deviation across different time periods, a table containing the significance results from simulation modelling analysis (SMA) and corresponding figures. Non-parametric statistical tests were used throughout the analysis due to the small sample size. All significance tests were subject to a Bonferroni correction of 0.0007 (Clark-Carter, 1997) to control for the number of tests administered. For clarity ACC will be referred to as “movement” in the text.

Participant 1

The HR of P1 (Table 6b) was significantly higher before the session began than during the first song therefore H1 was not supported. EDA and movement were higher during the first song, however these were not robustly significant. It is also worth noting that there was more variability in HR, EDA and movement during the first song compared to baseline.

HR and ST were significantly higher during the faster music than the slow, in partial support of H2. EDA was higher during the slower music, however this was not robustly significant. HR tended to increase in the first half of a new song regardless of the style.

Table 6a

Participant 1 (P1) Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	104.43	7.03	88.41	14.34	90.01	11.02	70.32	9.52
EDA	0.34	0.39	4.49	3.95	2.86	1.41	3.30	1.77
ACC	1.007	0.016	1.053	0.000	0.99	0.007	1.00	0.01
Temp	31.23	4.75	33.34	0.48	33.16	0.04	32.77	0.03

Table 6b

P1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	p	Rho	p
HR	-0.49	.0001**	-0.70	.0001**
EDA	0.55	.001*	0.30	.045*
ACC	0.40	.006*	0.15	.185
Temp	-0.08	.307	-0.862	.0001**

* p < .05

** p < .0007 Bonferroni correction

Figure 1a

Heart Rate of Participant 1 in Study 1 (P1S1) during Baseline, First Song, Fast Music and Slow Music

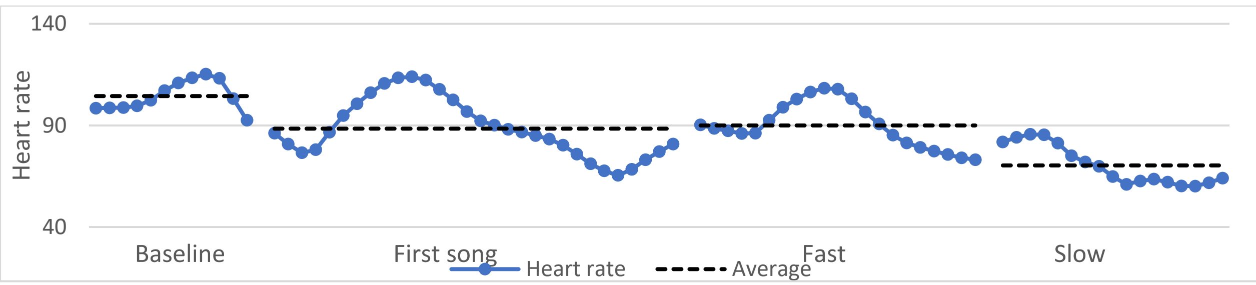


Figure 1b

EDA of P1S1 during Baseline, First Song, Fast Music and Slow Music

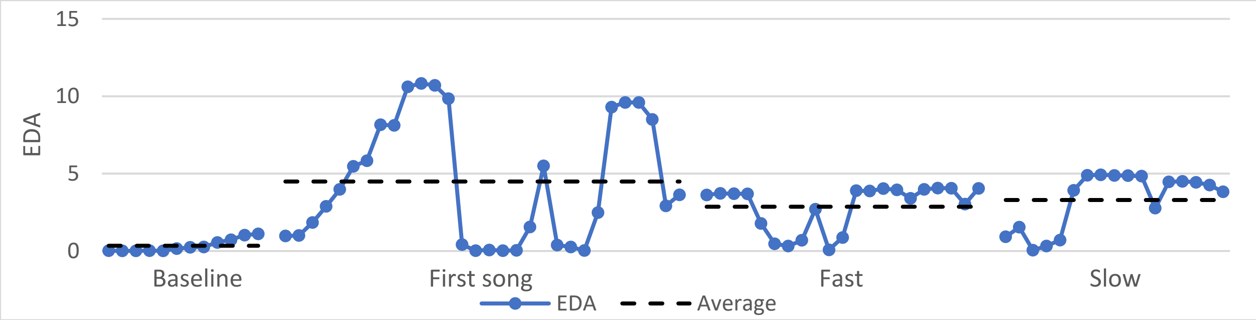


Figure 1c

ACC of P1S1 during Baseline, First Song, Fast Music and Slow Music

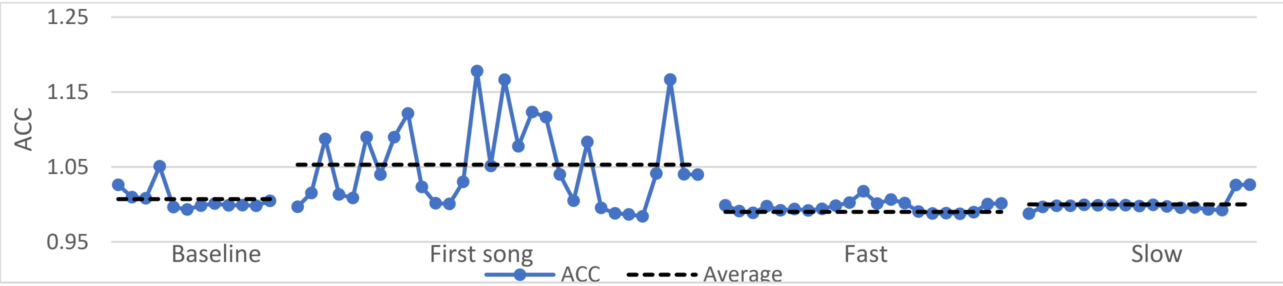
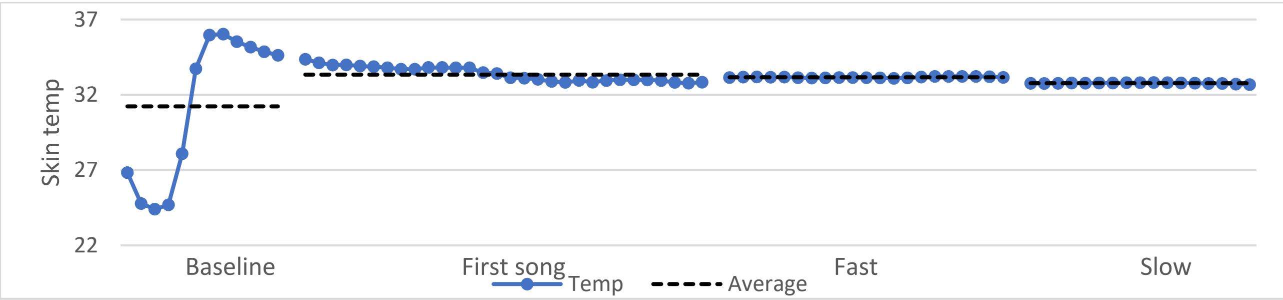


Figure 1d

ST of P1S1 during Baseline, First Song, Fast Music and Slow Music



Participant 2

Only EDA was significantly higher during the first song after Bonferroni correction. ST and movement were significantly lower, therefore H1 was not supported. There was also little difference between physiological responses during the two types of music. There was a peak in movement towards the end of the fast song, however no significant difference in movement overall.

Table 7a

P2S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	70.62	2.21	79.14	11.17	74.35	3.99	74.48	4.05
EDA	0.121	0.001	0.133	0.001	0.195	0.017	0.252	0.071
ACC	0.993	0.003	0.986	0.004	0.996	0.019	0.990	0.009
Temp	30.34	0.03	29.96	0.30	29.80	0.18	29.74	0.09

Table 7b

P2S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.35	.008*	0.06	.367
EDA	0.77	.0001**	0.37	.009*
ACC	-0.70	.0001**	-0.08	.315
Temp	-0.71	.0001**	-0.21	.099

* p < .05

** p < .0007 Bonferroni correction

Figure 2a

Heart Rate of P2S1 during Baseline, First Song, Fast Music and Slow Music

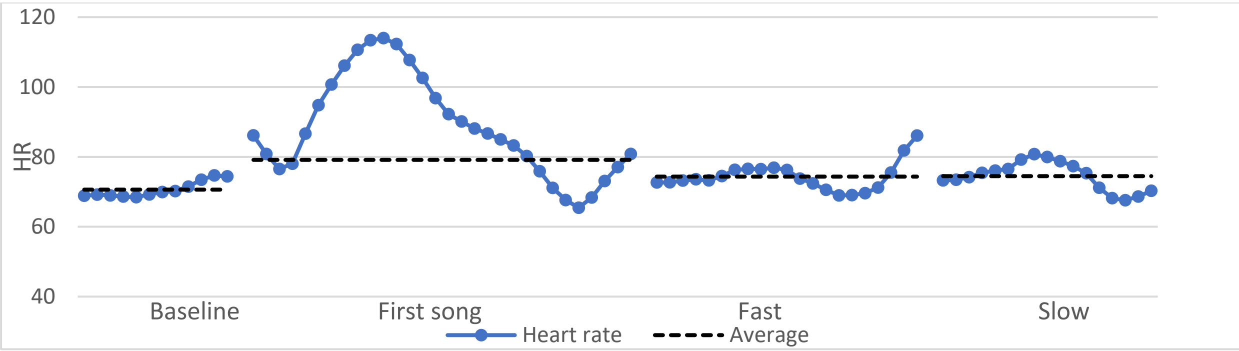


Figure 2b

EDA of P2S1 during Baseline, First Song, Fast Music and Slow Music

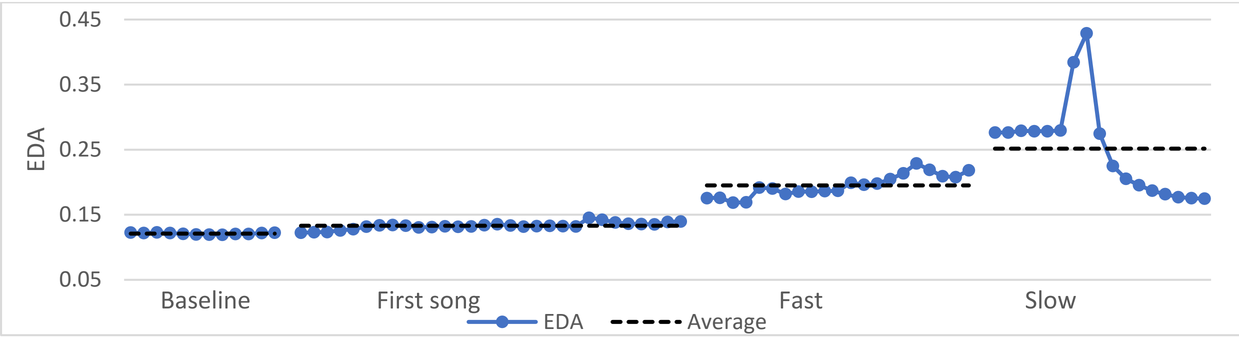


Figure 2c

ACC of P2S1 during Baseline, First Song, Fast Music and Slow Music

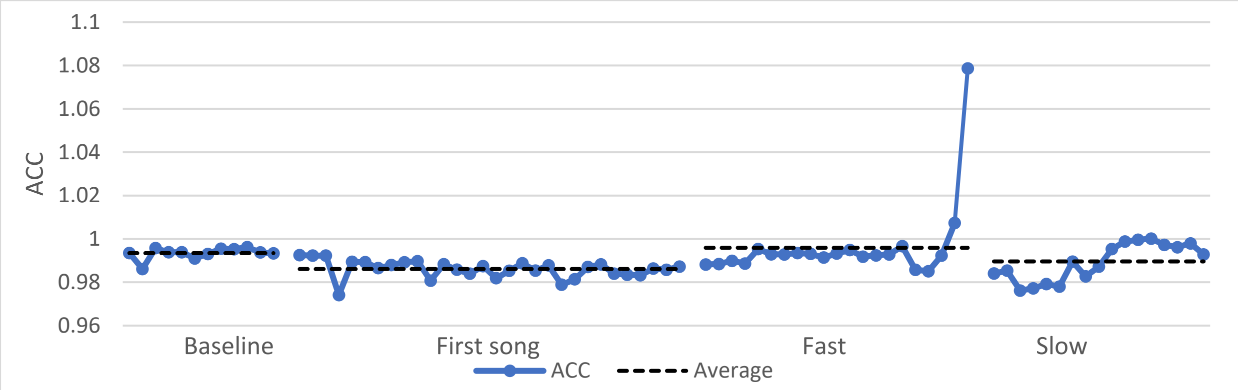
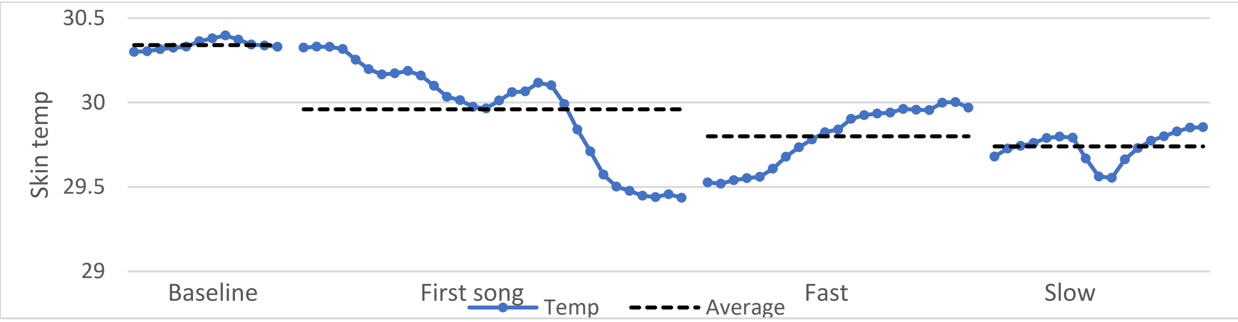


Figure 2d

ST of P2S1 during Baseline, First Song, Fast Music and Slow Music



Participant 3

Supporting H1, HR, EDA and movement were significantly higher during the first song compared to baseline. HR followed a pattern of a peak and decline throughout the song.

EDA was significantly higher during the fast than the slow music, partially supporting H2. There were no other significant differences between the measures during the two different styles of music.

Table 8a

P3S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	78.49	2.94	104.62	11.23	87.92	4.64	85.00	7.30
EDA	0.197	0.181	1.350	0.340	3.275	0.524	1.812	0.532
ACC	0.988	0.014	1.096	0.091	1.015	0.005	1.012	0.011
Temp	32.57	0.33	32.43	0.30	31.87	0.08	31.84	0.13

Table 8b

P3S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.77	.0001**	-0.17	.134
EDA	0.78	.0001**	-0.86	.0001**
ACC	0.70	.0001**	-0.01	.459
Temp	-0.22	.067	-0.14	.177

* $p < 0.05$

** $p < 0.0007$ Bonferroni correction

Figure 3a

Heart Rate of P3S1 during Baseline, First Song, Fast Music and Slow Music

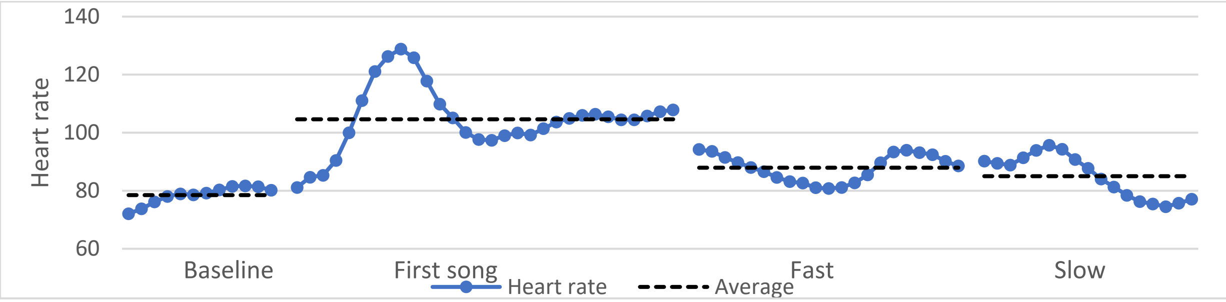


Figure 3b

EDA of P3S1 during Baseline, First Song, Fast Music and Slow Music

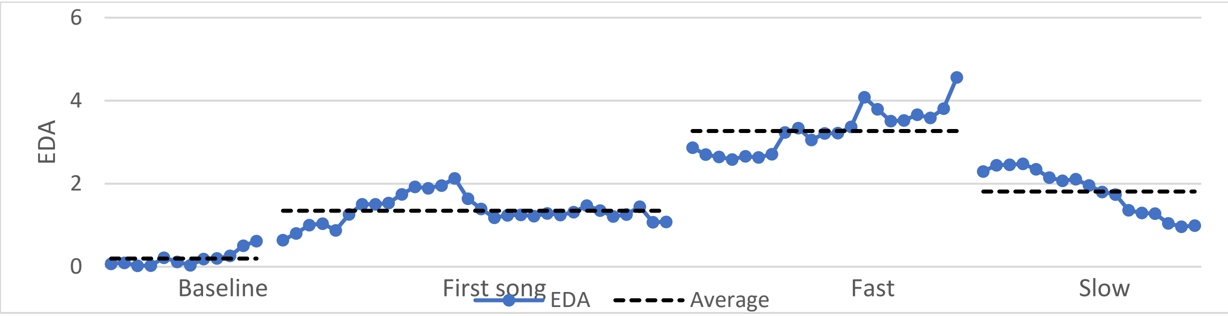


Figure 3c

ACC of P3S1 during Baseline, First Song, Fast Music and Slow Music

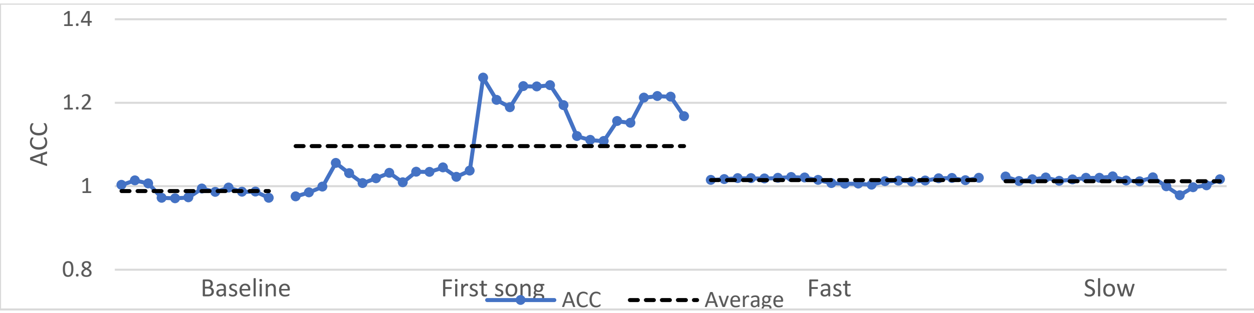
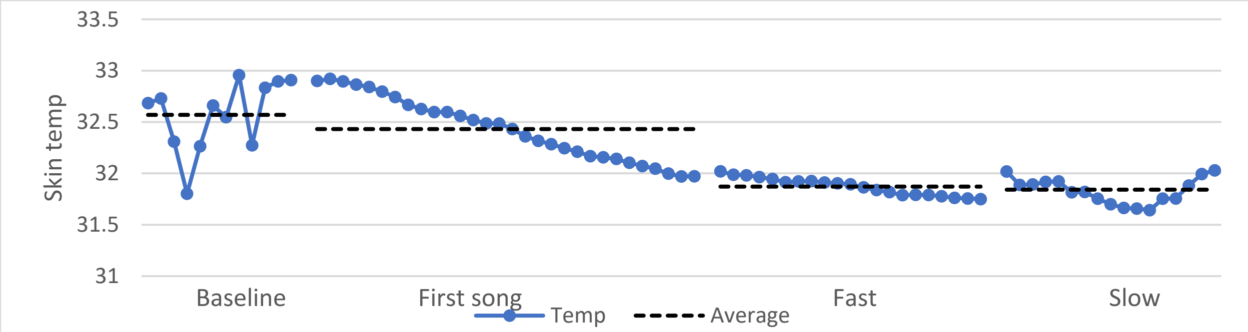


Figure 3d

Skin temp of P3S1 during Baseline, First Song, Fast Music and Slow Music



Participant 4

H1 was only supported by the changes in EDA, which were significantly higher during the first song. ST and movement were significantly lower, however movement was not robustly significant. EDA and ST were significantly lower during the slow music than during the fast, therefore H2 was partially supported. Movement was also lower, however this was not robustly significant.

Table 9a

P4S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	63.62	2.52	69.43	9.08	56.27	2.79	58.39	5.13
EDA	0.124	0.001	0.141	0.011	0.205	0.008	0.104	0.007
ACC	0.902	0.029	0.748	0.161	0.925	0.084	0.836	0.075
Temp	28.35	0.04	27.96	0.14	31.93	0.06	28.87	0.05

Table 9b

P4S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.23	.08	0.17	.151
EDA	0.75	.0001**	-0.86	.0001**
ACC	-0.45	.001*	-0.49	.001*
Temp	-0.78	.0001**	-0.86	.0001**

* p < 0.05

** p < 0.0007 Bonferroni correction

Figure 4a

Heart rate of PS41 during Baseline, First Song, Fast Music and Slow Music

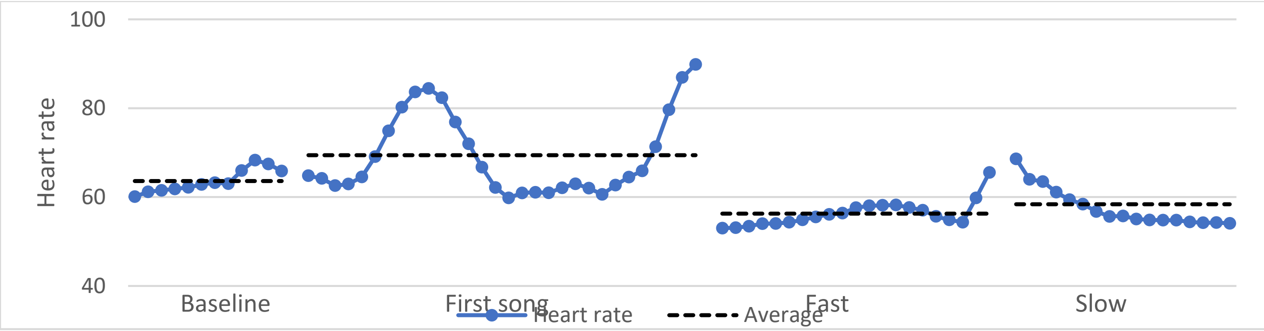


Figure 4b

EDA of P4S1 during Baseline, First Song, Fast Music and Slow Music

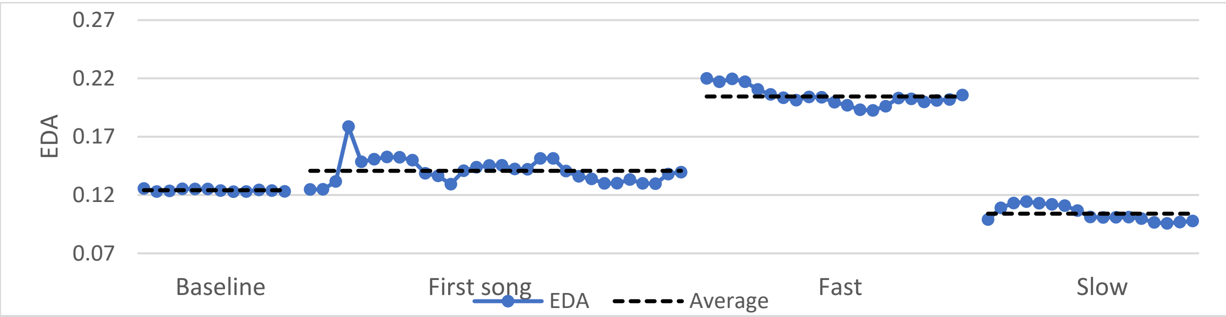


Figure 4c

ACC of P4S1 during Baseline, First Song, Fast Music and Slow Music

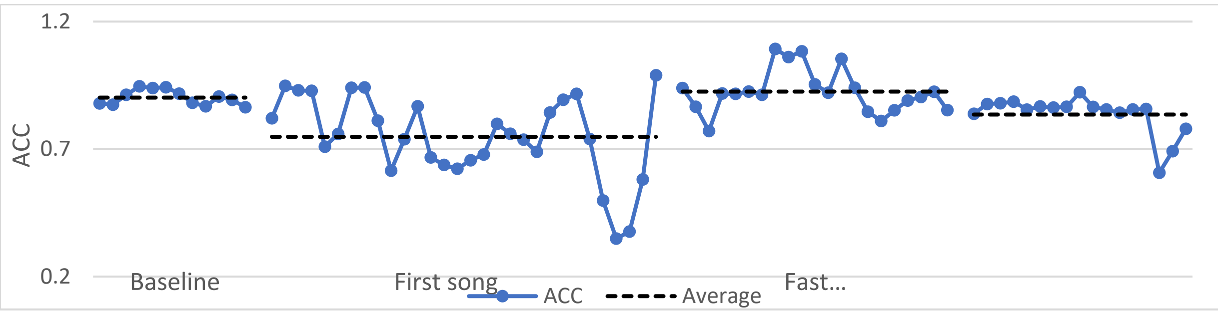
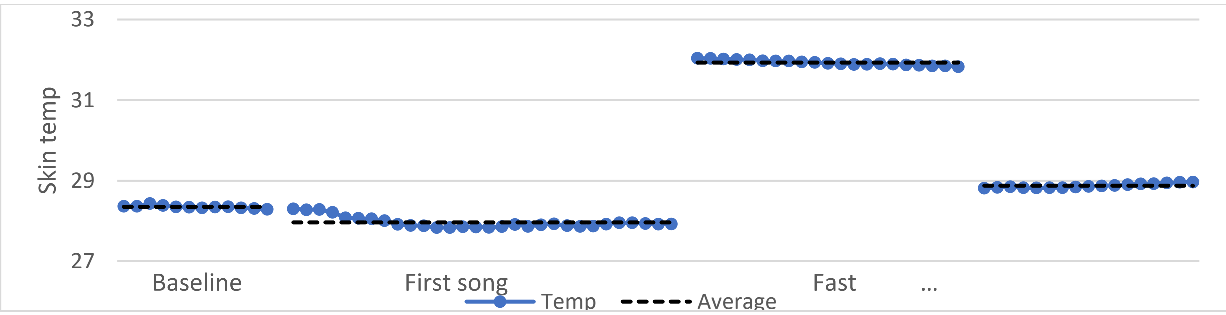


Figure 4d

Skin Temp of P4S1 during Baseline, First Song, Fast Music and Slow Music



Participant 5

In partial support of H1, HR and EDA were significantly higher during the first song compared to baseline. HR appeared to already be increasing before the first song began and then decreased after a peak. EDA and ST were both significantly higher during the slow music than the fast, partially supporting H2.

Table 10a

P5S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	68.67	9.22	79.55	6.03	83.99	13.81	84.17	9.10
EDA	0.099	0.057	0.888	0.050	0.009	0.001	1.015	0.285
ACC	0.981	0.006	0.996	0.193	0.986	0.002	0.982	0.006
Temp	33.16	0.34	33.09	0.31	32.96	0.08	33.28	0.068

Table 10b

P5S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.50	.0001**	0.05	.40
EDA	0.73	.0001**	0.86	.0001**
ACC	0.40	.001*	-0.27	.06
Temp	-0.10	.29	0.86	.0001**

* $p < 0.05$

** $p < 0.0007$ Bonferroni correction

Figure 5a

Heart rate of P5S1 during Baseline, First Song, Fast Music and Slow Music

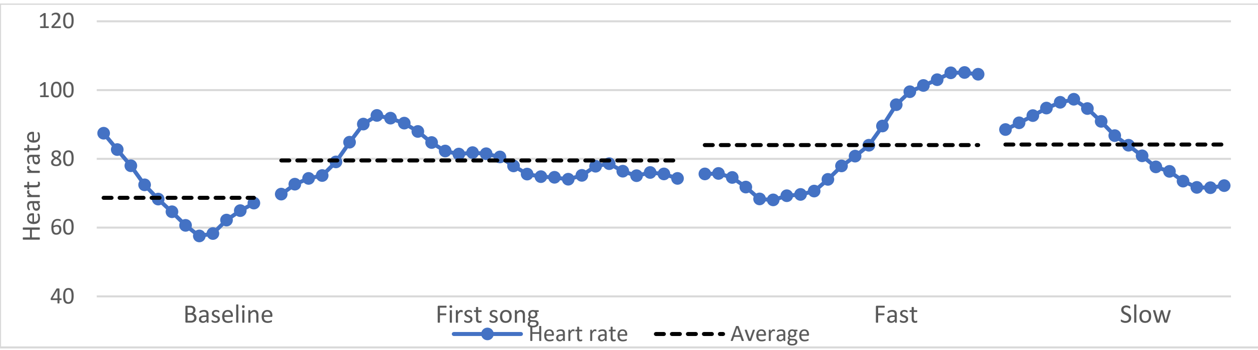


Figure 5b

EDA of P5S1 during Baseline, First Song, Fast Music and Slow Music

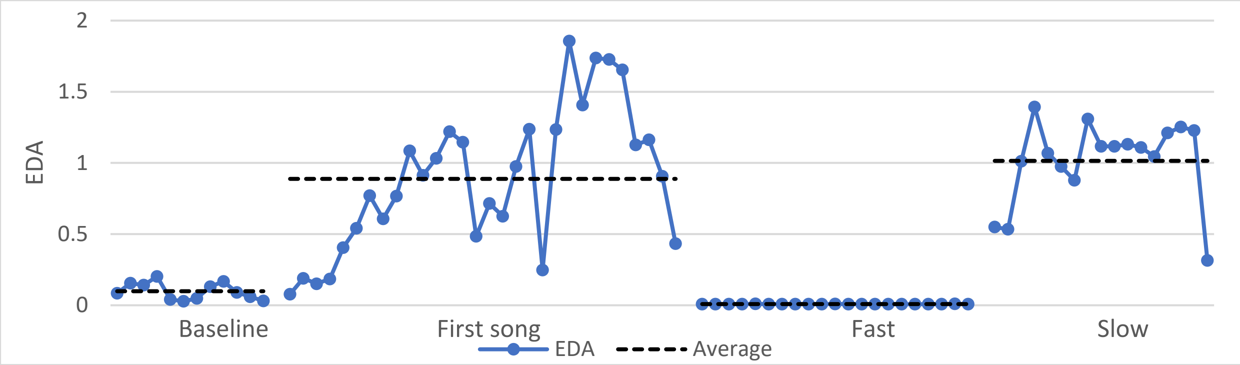


Figure 5c

ACC of P5S1 during Baseline, First Song, Fast Music and Slow Music

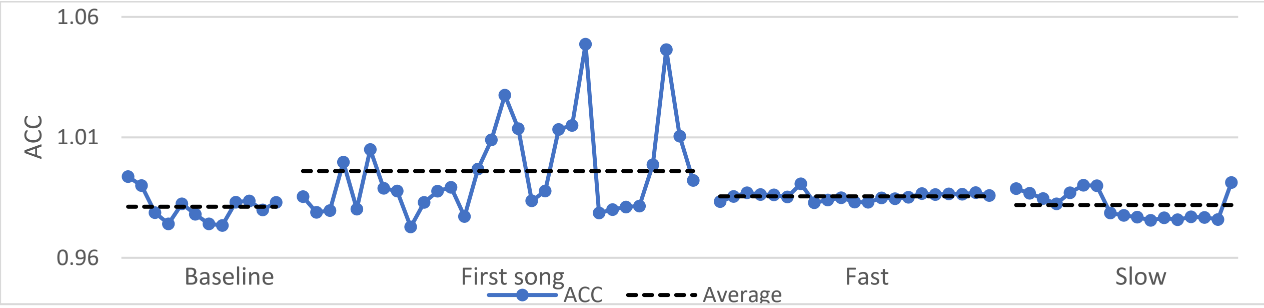
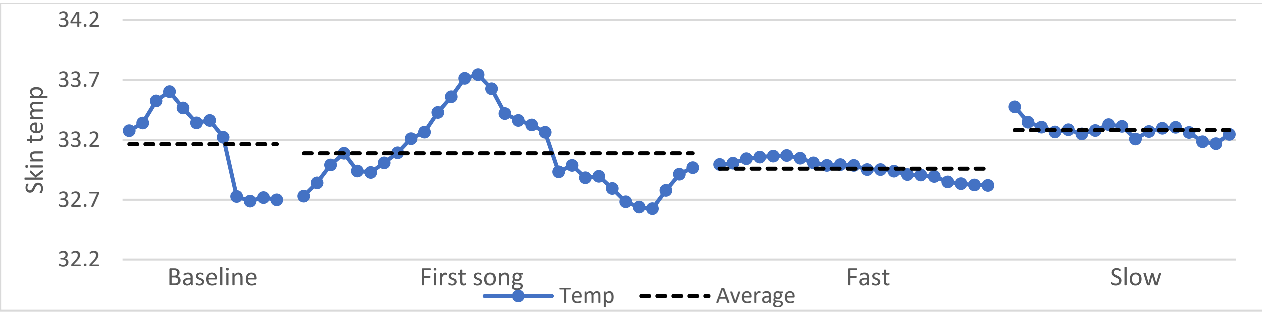


Figure 5d

ST of P5S1 during Baseline, First Song, Fast Music and Slow Music



Participant 6

Consistent with H1, HR, EDA and ST were significantly higher during the first song compared to baseline, however movement was significantly lower. Supporting H2, HR, EDA, movement and ST were all significantly lower during the slow song than the fast.

Table 11a

P6S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	69.92	7.73	79.64	5.94	94.22	8.89	78.34	5.34
EDA	0.135	0.002	0.170	0.017	0.364	0.088	0.155	0.004
ACC	1.352	0.013	1.019	0.128	1.181	0.016	0.155	0.004
Temp	28.07	0.05	28.50	0.12	31.01	0.03	29.25	0.15

Table 11b

P6S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.565	0.0001**	-0.755	0.0001**
EDA	0.67	0.0001**	-0.861	0.0001**
ACC	-0.78	0.0001**	-0.855	0.0001**
Temp	0.78	0.0001**	-0.864	0.0001**

* p < 0.05

** p < 0.0007 Bonferroni correction

Figure 6a

Heart rate of P6S1 during Baseline, First Song, Fast Music and Slow Music

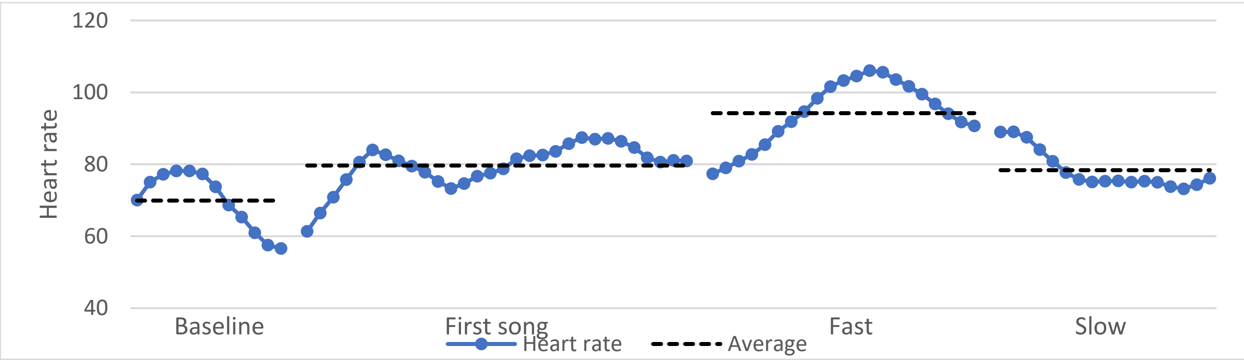


Figure 6b

EDA of P6S1 during Baseline, First Song, Fast Music and Slow Music

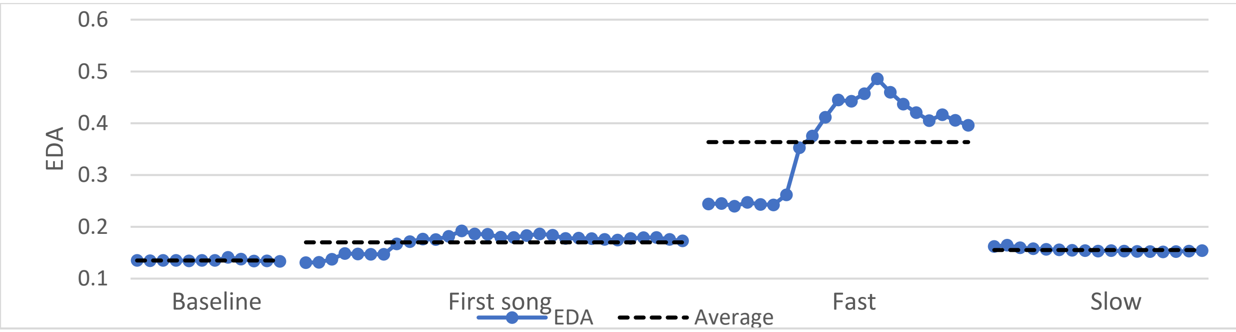


Figure 6c

ACC of P6S1 during Baseline, First Song, Fast Music and Slow Music

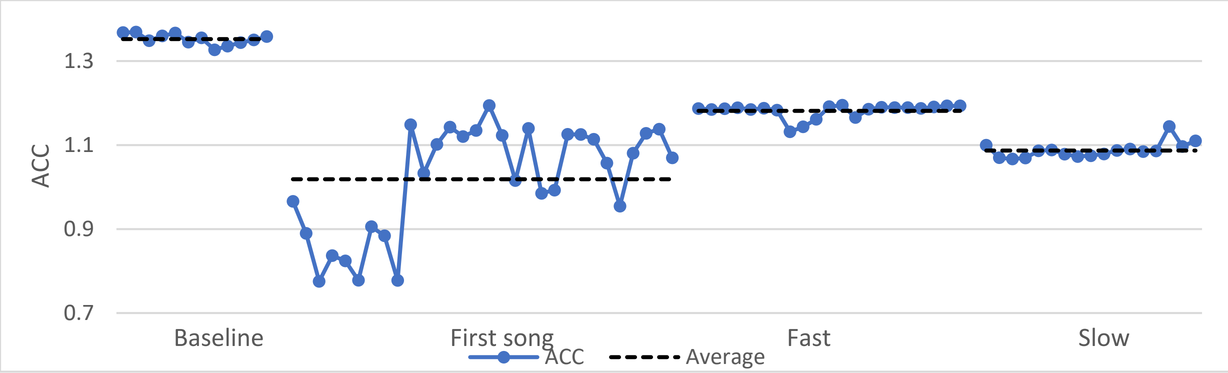
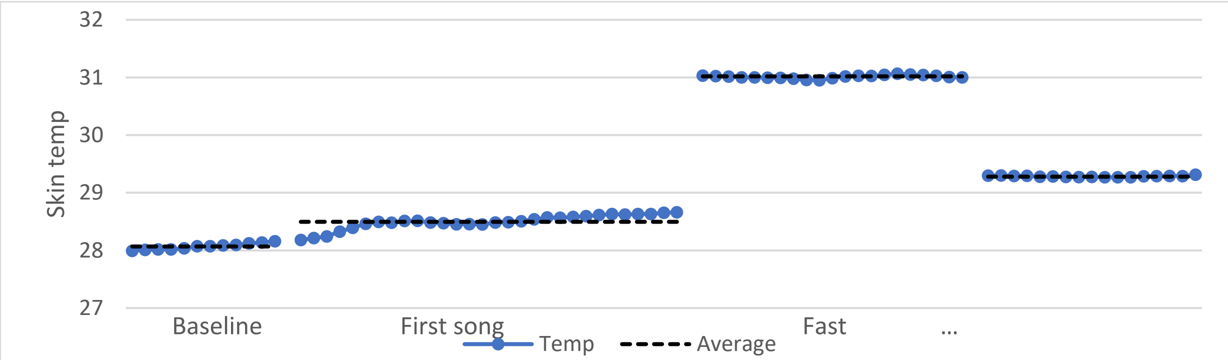


Figure 6d

ST of P6S1 during Baseline, First Song, Fast Music and Slow Music



Participant 7

In partial support of H1, Movement and ST were significantly higher during the first song compared to baseline. There was no data available for the EDA over this time period. HR and ST were significantly higher during the fast music, whilst EDA was significantly lower, therefore H2 was partially supported.

Table 12a

P7S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	97.40	0.96	95.68	7.40	76.83	5.05	62.61	5.28
EDA	No Data		No data		0.714	0.192	1.285	0.380
ACC	0.99	0.000	0.10	0.003	0.997	0.004	0.999	0.001
Temp	22.55	0.20	23.48	0.92	32.39	0.16	31.94	0.02

Table 12b

P7S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.0239	.472	-0.78	.0001**
EDA	No Data	No Data	0.73	.0001**
ACC	0.78	.0001**	0.43	.005
Temp	0.63	.0001**	-0.78	.0001**

* $p < 0.05$

** $p < 0.0007$ Bonferroni correction

Figure 7a

Heart Rate of P7S1 during Baseline, First Song, Fast Music and Slow Music

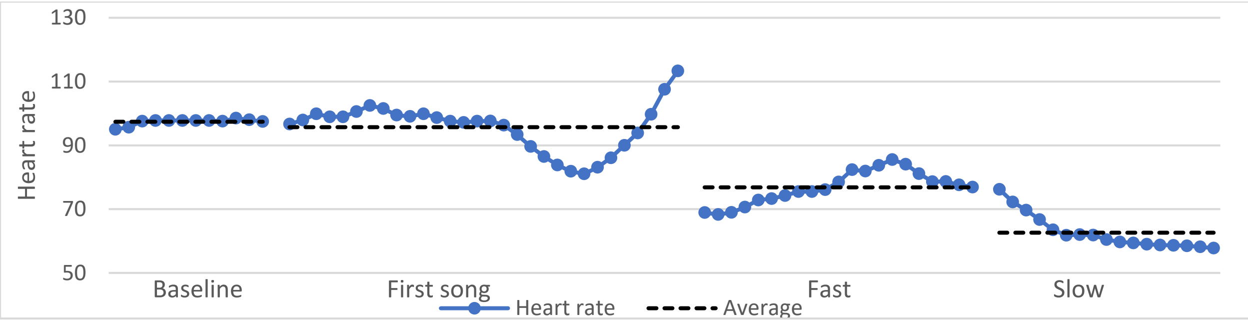


Figure 7b

EDA of P7S1 during Baseline, First Song, Fast Music and Slow Music

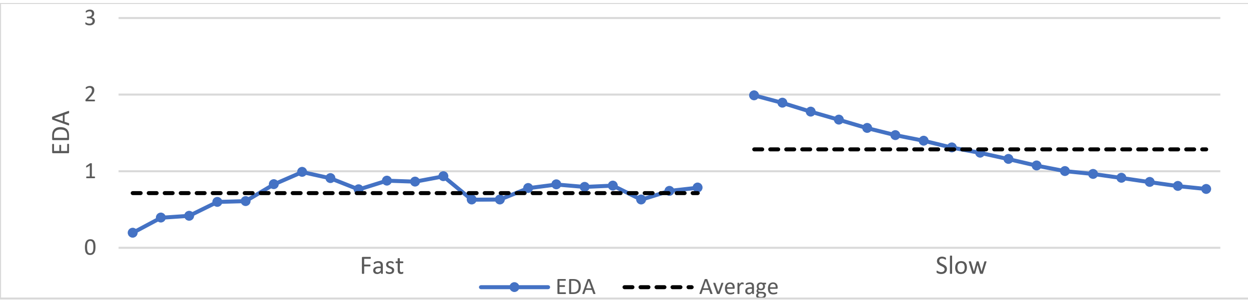


Figure 7c

Movement of P7S1 during Baseline, First Song, Fast Music and Slow Music

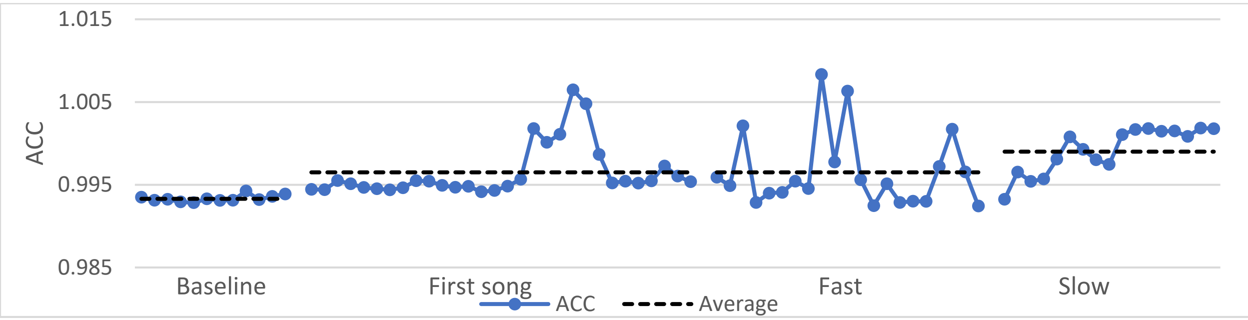
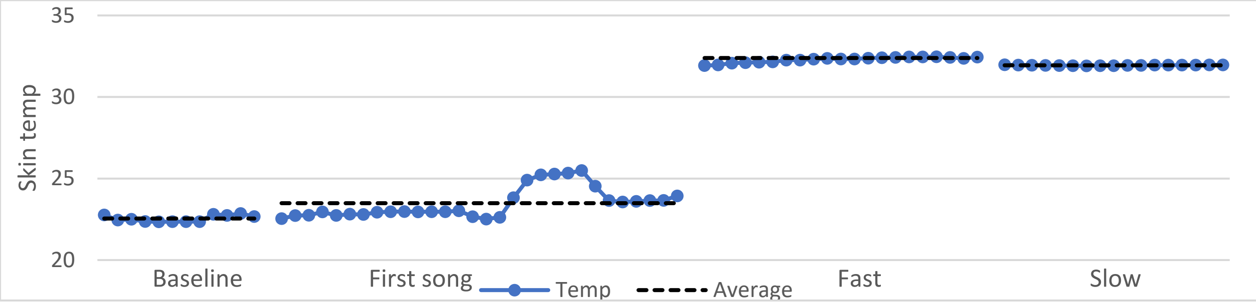


Figure 7d

Skin temp of P7S1 during Baseline, First Song, Fast Music and Slow Music



Participant 8

Consistent with H1, HR, EDA, movement and ST were all significantly higher during the first song compared to baseline. In partial support of H2, HR and ST were significantly higher during the fast music and EDA was significantly higher during the slow music.

Table 13a

P8S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	59.74	1.12	77.22	7.48	77.43	10.10	64.98	5.34
EDA	4.375	0.358	6.379	0.277	3.391	0.622	4.696	0.628
ACC	0.975	0.004	1.008	0.025	0.992	0.008	0.994	0.003
Temp	32.85	0.13	33.21	0.18	34.60	0.05	34.04	0.06

Table 13b

P8S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	0.76	.0001**	-0.5864	.0001**
EDA	0.79	.0001**	0.71	.0001**
ACC	0.76	.0001**	-0.06	.347
Temp	0.70	.0001**	-0.86	.0001**

* $p < 0.05$

** $p < 0.0007$ Bonferroni correction

Figure 8a

Heart Rate of P8S1 during Baseline, First Song, Fast Music and Slow Music

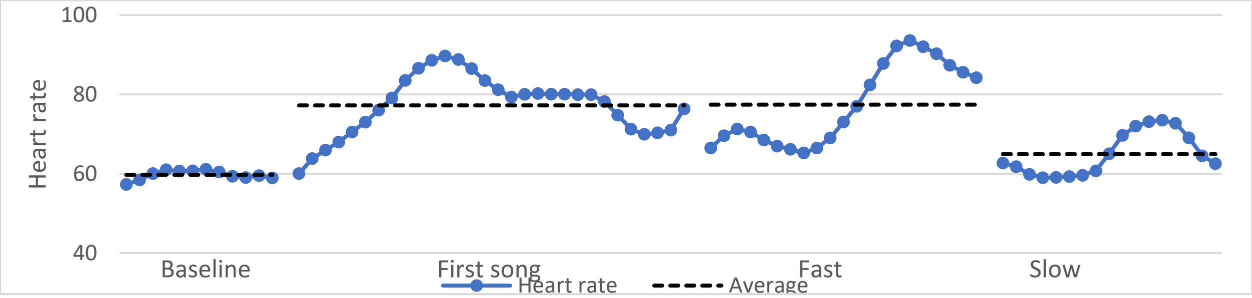


Figure 8b

EDA of P8S1 during Baseline, First Song, Fast Music and Slow Music

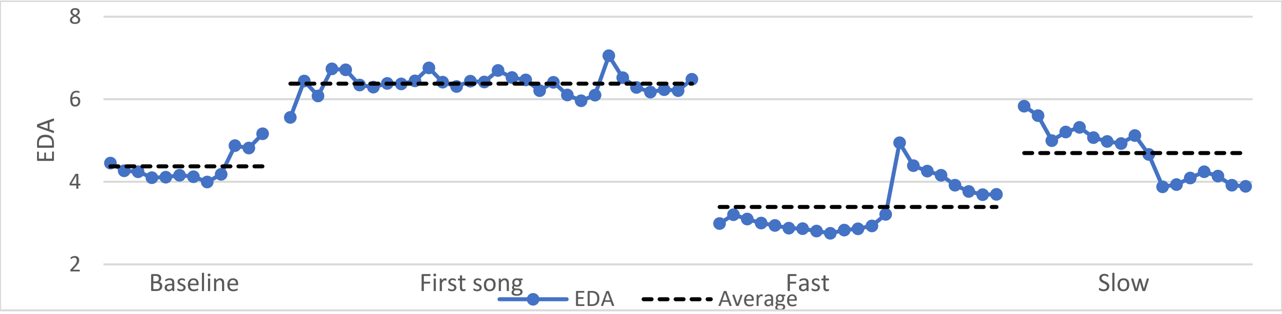


Figure 8c

ACC of P8S1 during Baseline, First Song, Fast Music and Slow Music

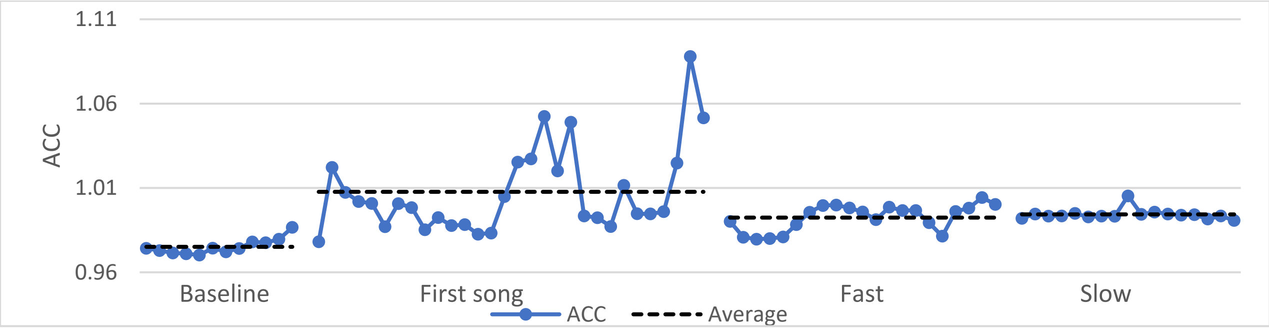
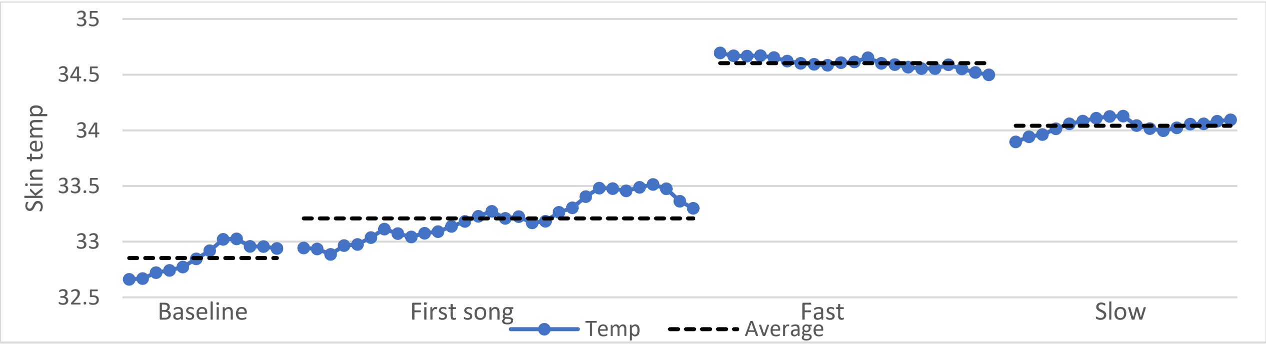


Figure 8d

ST of P8S1 during Baseline, First Song, Fast Music and Slow Music



Participant 9

Although EDA and ACC were found to be higher during the first song this was not robustly significant, therefore H1 was not supported. In partial support of H2, HR and ST were significantly higher during the fast song. Movement was significantly higher during the slow song.

Table 14a

P9S1 Descriptive Statistics of Physiological Measures

Measure	Baseline		First song		Fast		Slow	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	82.73	5.29	79.57	5.22	80.10	2.17	74.82	1.15
EDA	0.353	0.013	0.398	0.046	0.141	0.008	0.145	0.008
ACC	1.012	0.008	1.016	0.007	0.997	0.006	1.017	0.002
Temp	30.33	0.09	30.31	0.08	30.63	0.02	30.39	0.04

Table 14b

P9S1 Simulation Modelling Analysis Significance Tests

Measure	Baseline – first song		Fast - slow	
	Rho	Significance	Rho	Significance
HR	-0.24	.067	-0.83	.0001**
EDA	0.47	.001*	0.22	.093
ACC	0.31	.018*	0.79	.0001**
Temp	-0.17	.158	-0.86	.0001**

* $p < 0.05$

** $p < 0.0007$ Bonferroni correction

Figure 9a

Heart Rate of P9S1 during Baseline, First Song, Fast Music and Slow Music

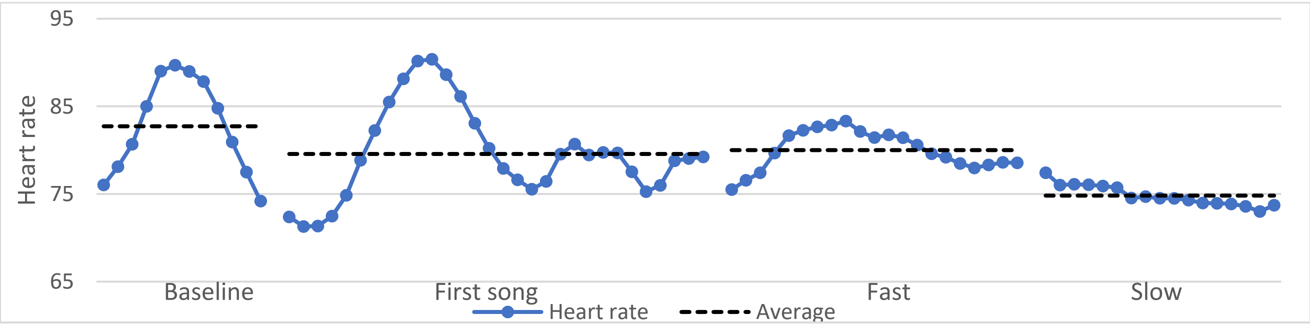


Figure 9b

EDA of P9S1 during Baseline, First Song, Fast Music and Slow Music

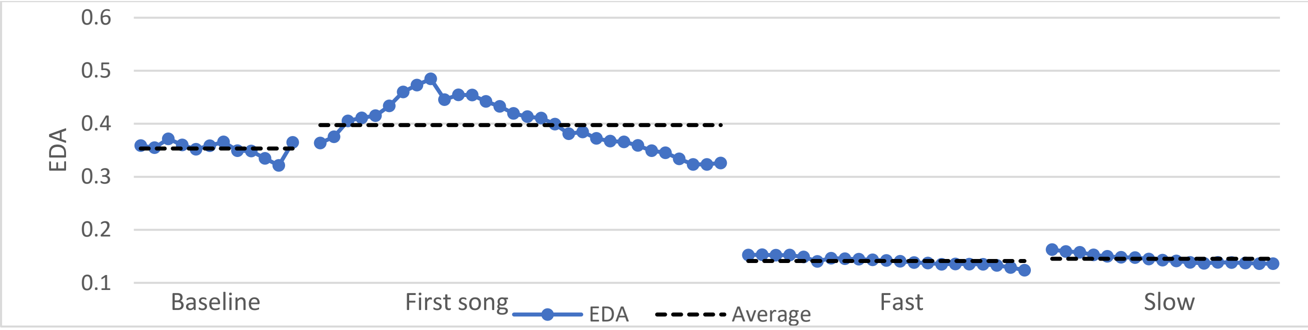


Figure 9c

ACC of P9S1 during Baseline, First Song, Fast Music and Slow Music

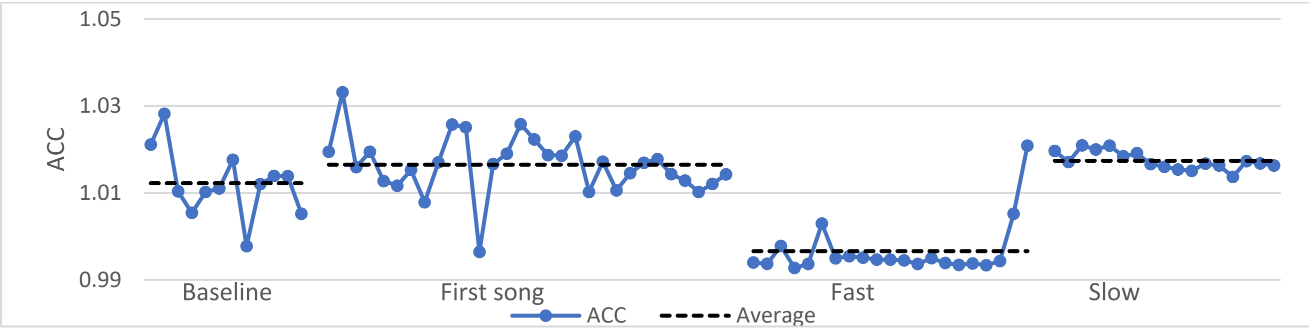
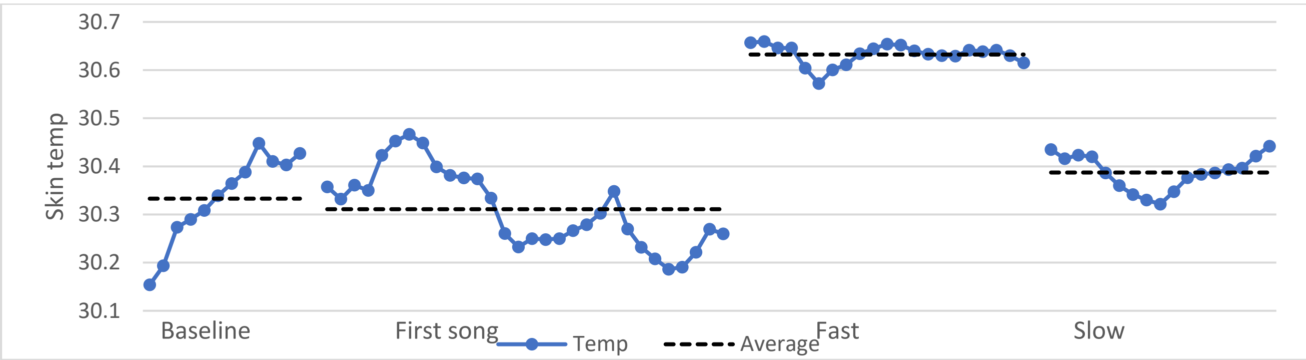


Figure 9d

ST of P9S1 during Baseline, First Song, Fast Music and Slow Music



Summary of physiological data for study 1

H1 stated that physiological measures will be significantly higher during the first song than before session began. The results summarizing the data from the case studies (Table 15) indicate that there was an overall increase in physiological measures during the first song compared to baseline, therefore H1 is partially supported. Amongst all nine case studies there were sixteen significantly higher results during the first song, compared to only four significantly lower responses. The most consistent change from baseline was a significant increase in EDA for seven of the eight participants with EDA recordings. Only one person had a decrease in HR during the first song and the data suggests a common pattern of HR increasing during the first half of the first song, then decreasing. The differences between ST and movement before and during the first song were mixed. Movement was higher during the first song for most participants, however three participants moved significantly less.

Table 15

Significance Results comparing Physiological Responses during the First Song to Baseline

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
HR	[dark red]	[light green]	[dark green]	[yellow]	[dark green]	[dark green]	[yellow]	[dark green]	[yellow]
EDA	[light green]	[dark green]	[dark green]	[dark green]	[dark green]	[dark green]	**N/a**	[dark green]	[light green]
ACC	[light green]	[dark red]	[dark green]	[red]	[light green]	[dark red]	[dark green]	[dark green]	[light green]
ST	[yellow]	[dark red]	[yellow]	[dark red]	[yellow]	[dark green]	[dark green]	[dark green]	[yellow]

[dark green] - Significantly higher during the first song after Bonferroni correction

[light green] - Significantly higher during the first song ($p < 0.05$)

[yellow] - No significant difference between before and during the first song

[red] – Significantly lower during the first song than baseline ($p < 0.05$)

[dark red] - Significantly lower during the first song after Bonferroni correction

H2 stated that there will be a significant difference between physiological measures during different styles of music. As can be seen in Table 16, the collated results are mixed. Overall, there were more robustly significant differences than not significant results which was consistent with H2, however the direction of significance varied. HR was significantly higher during the fast song than the slow for five participants and there were no contrasting results. ST was significantly higher during the fast song for six participants and during the slow for only one participant. EDA and ACC showed mixed results that did not support H2.

Table 16

Significance Results comparing Physiological Responses during the Fast and Slow Music

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
HR	[orange]					[orange]	[orange]	[orange]	[orange]
EDA	[light blue]	[light blue]	[orange]	[orange]	[dark blue]	[orange]	[dark blue]	[dark blue]	
ACC				[yellow]		[orange]			[dark blue]
ST	[orange]			[orange]	[dark blue]	[orange]	[orange]	[orange]	[orange]

[orange] - Significantly higher during the fast song after Bonferroni correction

[yellow] - Significantly higher during the fast song ($p < 0.05$)

[white] - No significant difference between before and during the first song

[light blue] – Significantly higher during the slow song than baseline ($p < 0.05$)

[dark blue] - Significantly higher during the slow song after Bonferroni correction

Study 2

This study consists of 6 participants where the same physiological data were collected during a control session and two intervention sessions of an interactive music group, but with people with more severe dementia. H3 and H4 are addressed in the first section before moving onto individual case studies of each participant within the sessions which addressed H5, H6 and H7. The final section addressed H8 by observing peaks in the data and how these relate to visible engagement.

Changes in physiological measures across sessions

HR. H3 stated that physiological responses during the intervention sessions will be significantly higher than during the intervention sessions. The HR of three participants was significantly higher during session 1 (P1S2, P3S2, P6S2) and session 6 (P1S2, P4S2, P6S2) compared to the control (Table 17). In contrast, the HR of two participants were significantly higher during the control than session 1, therefore H3 is not supported regarding HR. H4 stated that there will be no significant difference between physiological responses during the two intervention sessions. Five participants had a higher HR during session 1 than session 6 and two participants had a higher HR during session 6, therefore H4 was not supported.

Table 17

Mean and Standard Deviation of HR for all Participants during the First Song of Control and two Intervention Sessions

	Control		Session 1		Session 6	
	M	*SD*	*M*	*SD*	*M*	*SD*
P1S2	67.09	1.17	87.51	2.76	69.33	2.23
P2S2	104.21	26.26	57.70	0.52	53.84	0.83
P3S2	72.06	3.55	115.81	9.84	77.26	8.53
P4S2	69.24	10.27	67.03	9.14	75.10	8.92
P5S2	126.81	14.97	59.11	0.93	110.79	47.13
P6S2	60.04	2.51	170.15	10.64	101.91	16.53

Table 18

Significance Values of Comparisons between HR during the First Song of Control and two Intervention Sessions

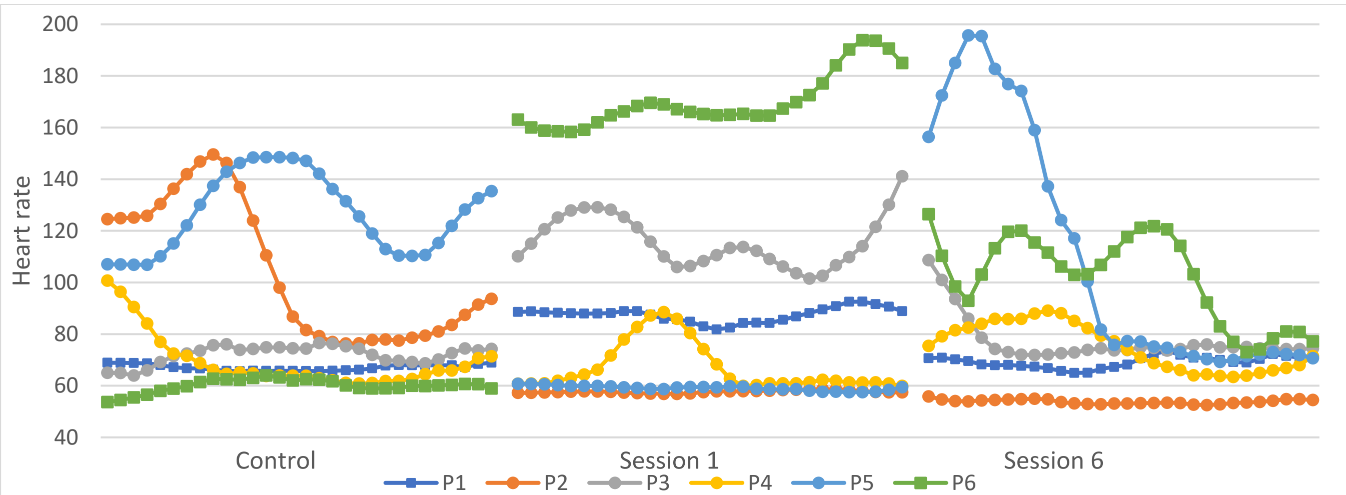
	Control – Session 1		Control – Session 6		Session 1 – Session 6	
	Rho	*Sig*	*Rho*	*Sig*	*Rho*	*Sig*
P1S2	0.87	.0001**	0.500	.0001**	-0.87	.0001**
P2S2	-0.87	.0001**	-0.87	.0001**	-0.87	.0001**
P3S2	0.87	.0001**	0.33	.003*	-0.85	.0001**
P4S2	-0.275	.017*	0.38	.001**	0.50	.0001**
P5S2	-0.87	.0001**	-0.26	.033*	0.61	.0001**
P6S2	0.87	.0001**	0.87	.001**	-0.87	.0001**

* p < .05

** p < .0027 Bonferroni correction

Figure 10

HR of all Participants during First Song of Control and Two Intervention Sessions



EDA. Consistent with H3, four participants had significantly higher EDA during the first session compared to the control, there was no robustly significant difference for two. Three participants had significantly higher EDA during session six than the control, whilst for P6S2, EDA was higher during the control than session 6. P1S2, P3S2 and P5S2 had significantly higher EDA during session 1 than 6, whilst the opposite was true for P4S2. H4 was therefore not supported.

Table 19

Mean and Standard Deviation of EDA for all Participants during the First Song of Control and Two Intervention Sessions

	Control		Session 1		Session 6	
	Average	*SD*	*Average*	*SD*	*Average*	*SD*
P1	0.224	0.011	0.374	0.010	0.265	0.009
P2	0.448	0.539	0.367	0.035	0.333	0.009
P3	0.032	0.018	0.089	0.017	0.013	0.008
P4	0.214	0.037	0.277	0.008	0.495	0.147
P5	0.031	0.001	0.108	0.002	0.018	0.018
P6	0.085	0.002	0.186	0.002	0.021	0.006

Table 20

Significance Values of Comparisons between EDA during the First Song of Control and Intervention Sessions

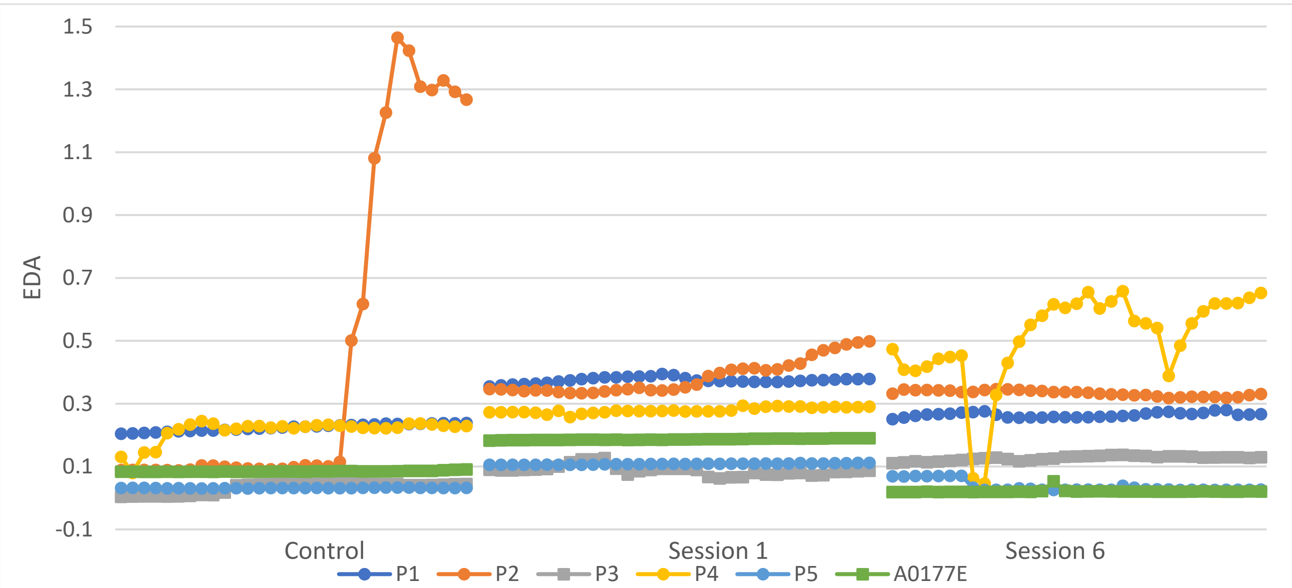
	Control – Session 1		Control – Session 6		Session 1 – Session 6	
	Rho	*Sig*	*Rho*	*Sig*	*Rho*	*Sig*
P1	0.87	.0001**	0.87	.0001**	-0.87	.0001**
P2	0.29	.007*	0.33	.003*	-0.29	.016
P3	0.87	.0001**	0.87	.0001**	-0.80	.001**
P4	0.87	.001*	0.75	.0001**	0.75	.0001**
P5	0.87	.0001**	-0.30	.01	-0.87	.0001**
P6	0.87	.0001**	-0.87	.0001**	-0.87	.0001

* p < .05

** p < .0027 Bonferroni correction

Figure 11

EDA of all Participants during First Song of Control and Two Intervention Sessions



Movement. Overall, there was more movement in the intervention sessions compared to the control in line with H3. Three of five participants showed more movement during the first session and four participants showed more movement during session 6 than the control. There was only one contrasting result who moved more during the control than session 1 (P1S2).

Consistent with H4, only two of five participants showed significant differences in movement between the two intervention sessions, one participant moved significantly more in session 6 (P1S2) and the other moved more in session 1 (P2S2).

Table 21

Mean and Standard Deviation of ACC for all Participants during the First Song of Control and Two Intervention Sessions

	Control		Session 1		Session 6	
	M	*SD*	*M*	*SD*	*M*	*SD*
P1	0.991	0.003	0.987	0.001	0.989	0.002
P2	0.986	0.005	1.009	0.002	0.990	0.001
P3	0.992	0.003	0.998	0.004	0.998	0.001
P4	0.972	0.003	No data	No data	1.017	0.006
P5	0.975	0.008	0.980	0.006	0.984	0.003
P6	0.982	0.002	0.994	0.002	0.993	0.015

Table 22

Significance Values of Comparisons between ACC during the First song of Control and Intervention Sessions

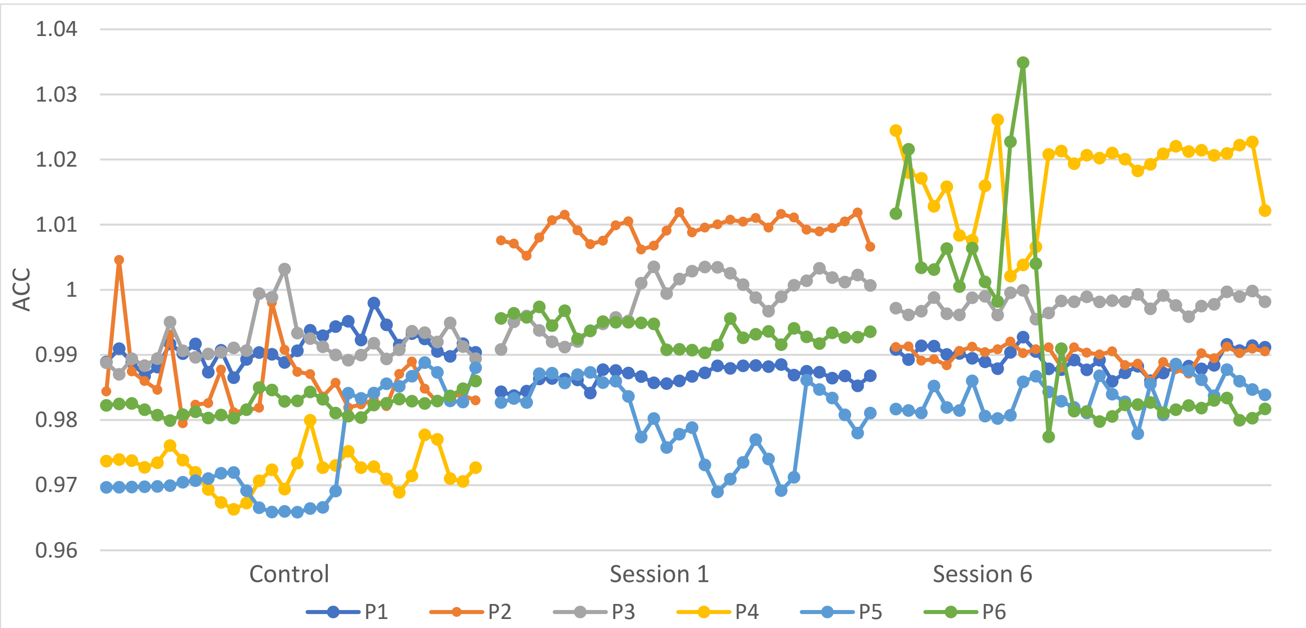
	Control – Session 1		Control – Session 6		Session 1 – Session 6	
	Rho	*Sig*	*Rho*	*Sig*	*Rho*	*Sig*
P1	-0.77	0.0001**	-0.37	0.001	0.65	0.001**
P2	0.8661	0.0001**	0.62	0.0001**	-0.8661	0.0001**
P3	0.6871	0.0001**	0.72	0.0001**	-0.15	0.112
P4	No data	No data	0.87	0.0001**	No data	No data
P5	0.32	0.01	0.43	0.0001**	0.30	0.008
P6	0.87	0.0001**	0.22	0.047	-0.17	0.106

* p < .05

** p < .0027 Bonferroni correction

Figure 12

ACC of all Participants during First Song of Control and Two Intervention Sessions



Skin temperature. Supporting H3, ST was higher during the intervention sessions than the control for all participants except P6S2 who had a lower ST in session 6 than the control (Table 24).

H4 was not supported, as three participants had a higher ST in session 1 than six and the remaining three had the opposite response.

Table 23

Mean and Standard Deviation of ST for all Participants during the First Song of Control and Two Intervention Sessions

	Control		Session 1		Session 6	
	M	*SD*	*M*	*SD*	*M*	*SD*
P1	30.32	0.07	33.32	0.04	32.72	0.01
P2	30.93	0.07	34.25	0.06	32.94	0.03
P3	29.26	0.01	30.10	0.26	31.61	0.11
P4	30.77	0.12	31.26	0.06	33.88	0.08
P5	27.41	0.03	29.96	0.04	31.30	0.40
P6	27.88	0.01	29.81	0.02	27.38	0.47

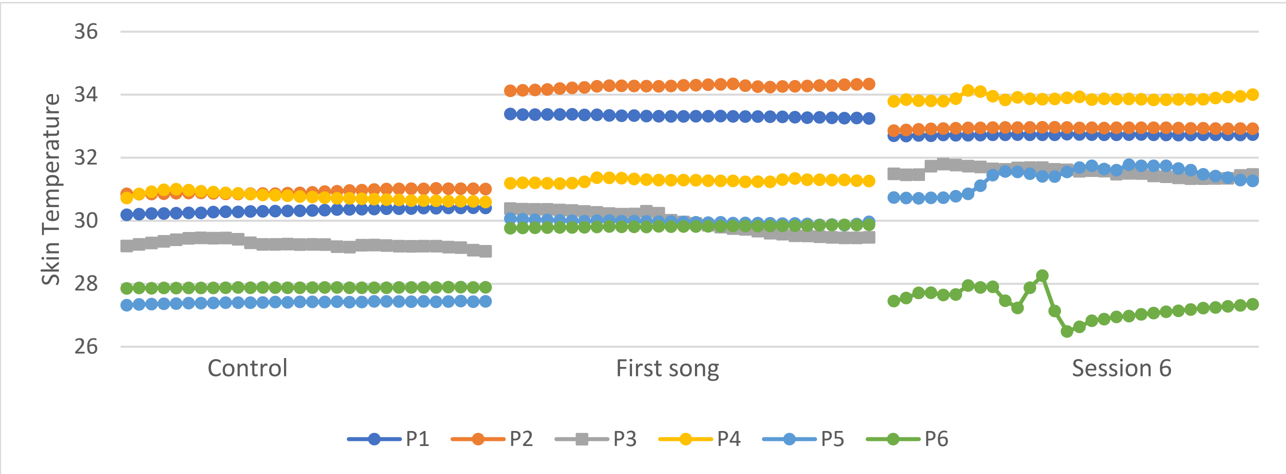
Table 24

Significance Values of Comparisons between ST during the First song of Control and Intervention Sessions

	Control – Session 1		Control – Session 6		Session 1 – Session 6	
	Rho	*Sig*	*Rho*	*Sig*	*Rho*	*Sig*
P1	0.87	.0001**	0.86	.0001**	-0.86	.0001**
P2	0.86	.0001**	0.86	.0001**	-0.86	.0001**
P3	0.86	.0001**	0.86	.0001**	0.86	.0001**
P4	0.86	.0001**	0.86	.0001**	0.86	.0001**
P5	0.86	.0001**	0.86	.0001**	0.86	.0001**
P6	0.86	.0001**	-0.53	.0001**	-0.86	.0001**

Figure 13

ST of all Participants during First Song of Control and Intervention Sessions



Engagement across sessions

The engagement of three participants was rated during fast and slow music of each session. The percentage of engagement for each participant can be seen below (Table 25).

There was an overall increase in engagement as the sessions progressed with the highest rated engagement occurring in session 6 (Figure 14).

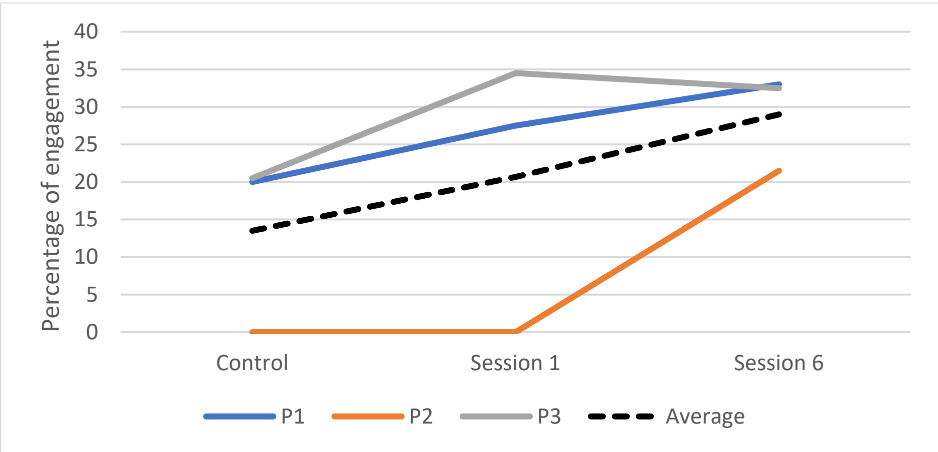
Table 25

Percentage of Engagement during Fast and Slow Music in the Control and Intervention Sessions

	Control		Session 1		Session 6	
	Positive	Negative	Positive	Negative	Positive	Negative
P1	20%	0%	27.5%	0%	33%	0%
P2	0%	0%	0%	0%	21.5%	0%
P3	20.5%	0%	34.5%	0%	32.5%	0%
Total	40.5	0	62	0	87	0

Figure 14

Percentage of Engagement during the Control and Intervention Sessions



Summary of physiological measures across sessions

Overall, physiological measures did appear to be elevated during the intervention sessions compared to the control session which is consistent with H3 (Table 26). EDA, movement and ST were more consistently higher during the intervention sessions whilst HR results were more mixed. Two participants responses were significantly higher across all four measures.

There was a significant difference between measures during the intervention sessions with more being significantly higher during session 1 than 6, therefore H4 was not supported. HR was higher for four participants and EDA was higher for three participants in session 1.

The average engagement was higher during the intervention sessions than the control session. All participants showed an increase in engagement as the intervention progressed.

Table 26

Significance Results Comparing Physiological Responses during the First Song of Intervention Sessions to the Control Session

Measure	Comparison	P1	P2	P3	P4	P5	P6
HR	Con < S1						
	Con < S6						
EDA	Con < S1						
	Con < S6						
ACC	Con < S1				N/a		
	Con < S6						
ST	Con < S1						
	Con < S6						

- Significantly higher during session 1 or 6 than control after Bonferroni correction

- Significantly higher during session 1 or 6 than control ($p < 0.05$)

- No significant difference between the intervention and control

– Significantly lower during session 1 or 6 than control ($p < 0.05$)

- Significantly lower during session 1 or 6 after Bonferroni correction

Individual case studies of physiological changes

Each participant's experience during the three sessions have been presented as individual case studies (Yin, 2003). These case studies will consider the same time frames as study 1 within all three sessions. In addition, qualitative observations of engagement will be included and the engagement of P1S2, P2S2 and P3S2 was rated more formally.

Participant 1

Physiological changes within the session. H5 stated that physiological responses would be higher during the first song than baseline. More physiological differences were present in the control session than the intervention sessions. In support of H5, EDA, ST and movement were all significantly higher during the first song of the control session, however HR was significantly lower. During the intervention sessions, only a significant increase in EDA during the first song of both intervention sessions and ST during session 6 were consistent with H5. ST was significantly lower during the first song of session 1.

H6 stated that physiological responses will differ during fast and slow music. HR, EDA and movement were all significantly higher and ST was significantly lower during the slow music of the control. HR, EDA and ST were significantly higher during the fast music of session 1. In session 6, ST was significantly higher, therefore H6 was partially supported.

Engagement. During the control session, P1S2 appeared marginally more engaged during the slow music; she was more focused on others, touched the hand of a staff member, smiled and tapped her toe. During the faster music she tapped her toe to the music and leaned forward. She scored higher for engagement during the intervention sessions due to her interaction with instruments, either playing them or holding them in her lap.

H7 stated that changes in physiological responses will be associated with visible engagement. Although higher physiological measures were associated with higher engagement in the control session, the opposite was true in session 1, therefore H7 was not supported. Session 6 showed the least difference between music styles and there was also no difference in the percentage of engagement.

Table 27a

P1S2 Mean and Standard Deviation of Physiological Responses

Measure	Session	Baseline		First song		Fast		Slow	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	Control	79.20	12.53	67.15	1.20	66.89	0.62	68.36	0.80
	S1	90.81	3.21	87.35	2.78	69.50	5.40	69.50	5.40
	6	68.72	1.94	69.33	2.23	67.54	8.22	71.63	5.34
EDA	Control	0.1890	0.010	0.224	0.011	0.280	0.004	0.310	0.004
	1	0.202	0.055	0.264	0.008	0.328	0.006	0.323	0.004
	6	0.2650	0.007	0.264	0.007	0.261	0.029	0.202	0.055
ACC	Control	0.988	0.001	0.991	0.002	0.984	0.002	0.987	0.003
	1	0.984	0.003	0.987	0.001	0.992	0.007	0.991	0.001
	6	0.991	0.002	0.989	0.002	0.996	0.996	1.000	0.001
Temp	Control	30.08	0.05	31.52	6.66	30.20	0.02	30.07	0.03
	1	33.41	0.01	33.32	0.04	32.85	0.03	32.80	0.01
	6	32.67	0.01	32.73	0.01	32.88	0.05	32.97	0.02

Table 27b

P1S2 Significance Values Comparing Physiological Responses

Measure		Baseline – first song		Fast - slow	
		Rho	*p*	*Rho*	*p*
HR	Control	-0.73	.0001**	0.69	.0001**
	Session 1	-0.42	.002*	-0.82	.0001**
	Session 6	0.14	.183	0.23	.034*
EDA	Control	0.79	.0001**	0.87	.0001**
	Session 1	0.47	.0001**	-0.41	.0001**
	Session 6	0.46	.0001**	-0.58	.0001*
ACC	Control	0.47	.0001**	0.41	.001**
	Session 1	0.45	.001	0.15	.145
	Session 6	-0.330	.019*	0.15	.183
Temp	Control	0.79	.0001**	-0.86	.0001**
	Session 1	-0.78	.0001**	-0.77	.0001**
	Session 6	0.78	.0001**	0.75	.0001**

* < .05

** < .0007 Bonferroni correction

Figure 15a

P1S2 HR during Control and Two Intervention Sessions

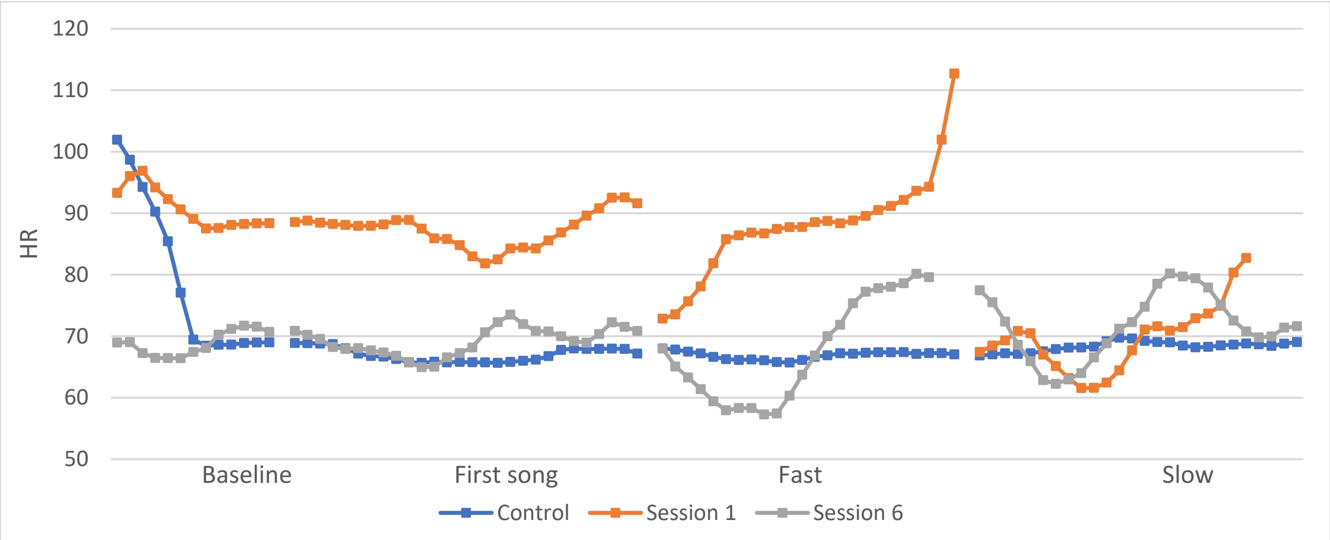


Figure 15b

P1S2 EDA during Control and Two Intervention Sessions

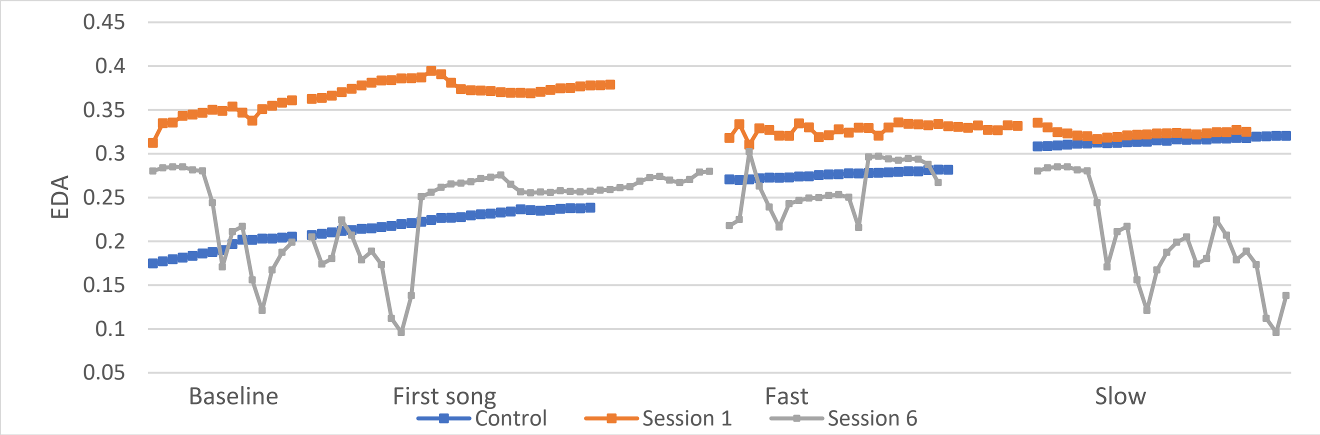


Figure 15c

P1S2 ST during Control and Two Intervention Sessions

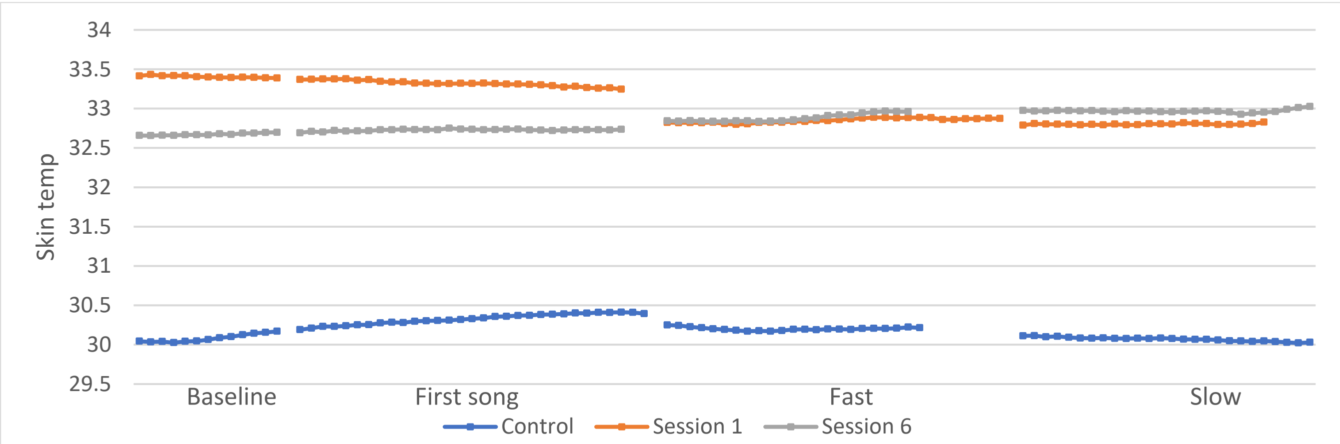


Figure 15d

P1S2 ACC during control and two intervention sessions

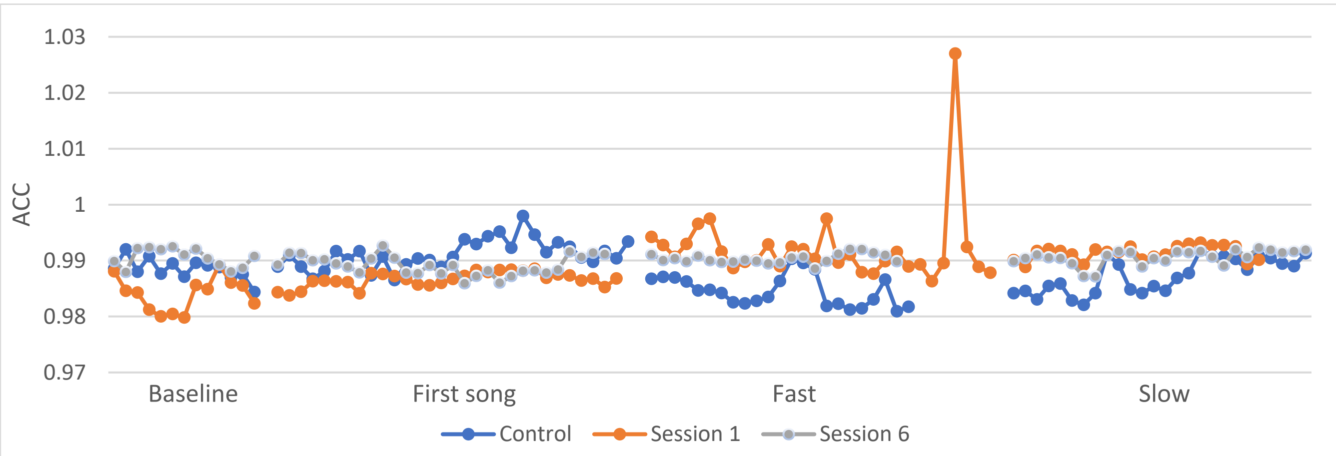


Table 27c

P1S2 Engagement Ratings during Fast and Slow Music of Control and Intervention Sessions

	Control		Session 1		Session 6	
	Fast	Slow	Fast	Slow	Fast	Slow
Song length	225s	252s	335s	214s	214s	255s
Positive engagement	220s (17%)	1512s (23%)	2010s (20%)	453s (35%)	418s (33%)	510 (33%)
Negative engagement	0(0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Participant 2

Physiological changes within the session. There were no robustly significant differences between physiological measures during baseline and the first song of the control. Partially supporting H5, ST was significantly higher during the first song of session 1 and EDA was significantly higher during session 6. In contrast, ST was significantly lower during the first song of session 6.

Physiological responses differed more during fast and slow music during the control session compared to the intervention sessions. HR and movement were significantly higher during the fast music, whilst EDA and ST were significantly higher during the slow music in both control and session 6. There were no significant differences present during session 1.

Engagement. P2S2 remained still throughout both styles of music in the control session with his eyes closed, smiling briefly as the slower song began. He was similarly still during both songs in session 1 although he looked at an instrument briefly. In session 6 he was more visually alert and drank a cup of tea. He watched facilitators playing various instruments at points yet did not physically engage with them.

Rated engagement did not relate to physiological measures therefore H7 was not supported. In the control session, P2S2 showed significant differences in responses during fast and slow music but there was no visible engagement. In session 1, there was no difference between engagement or physiological responses. In session 6, EDA and ST was higher during slow music, however he appeared slightly more engaged during the faster music.

Table 28a

P2S2 Mean and Standard Deviation of Physiological Responses

Measure	Session	Baseline		First song		Fast		Slow	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	Control	140.17	11.47	104.21	26.26	76.18	3.83	70.94	1.56
	1	57.83	0.61	57.70	0.52	54.10	1.58	57.79	8.89
	6	57.37	0.30	58.69	3.34	58.62	2.54	60.44	1.18
EDA	Control	0.091	0.002	0.448	0.531	0.499	0.049	0.597	0.103
	1	0.347	0.005	0.371	0.039	1.468	0.213	1.447	0.279
	6	0.319	0.008	0.334	0.009	0.740	0.306	1.220	1.220
ACC	Control	0.983	0.002	0.986	0.005	0.985	0.001	0.983	0.001
	1	1.010	0.003	1.009	0.002	1.006	0.003	1.008	0.001
	6	1.006	0.003	1.008	0.001	0.987	0.006	0.990	0.006
Temp	Control	30.87	0.01	30.93	0.07	31.479	0.032	31.526	0.016
	1	34.05	0.03	34.27	0.06	33.856	0.048	33.845	0.029
	6	32.92	0.07	32.73	0.01	32.945	0.070	33.116	0.042

Table 28b

P2S2 Significance Values comparing Physiological Responses

Measure	Session	Baseline – first song		Fast - slow	
		Rho	*p*	*Rho*	*p*
HR	Control	-0.57	.001*	-0.70	.0001**
	Session 1	-0.04	.40	-0.10	.25
	Session 6	0.55	.003*	0.33	.007*
EDA	Control	0.46	.002*	0.51	.0001**
	Session 1	0.09	.317	0.24	.101
	Session 6	0.60	.0001**	0.83	.0001**
ACC	Control	0.21	.097	-0.68	.0001**
	Session 1	-0.12	.217	0.24	.056
	Session 6	0.24	.056	0.14	.165
Temp	Control	0.29	.027	0.87	.0001**
	Session 1	0.78	.0001**	-0.17	.125
	Session 6	-0.78	.0001**	0.86	.0001**

* P < .05

** P < .0007 Bonferroni correction

Figure 16a

P2S2 Heart Rate during Control and Two Intervention Sessions

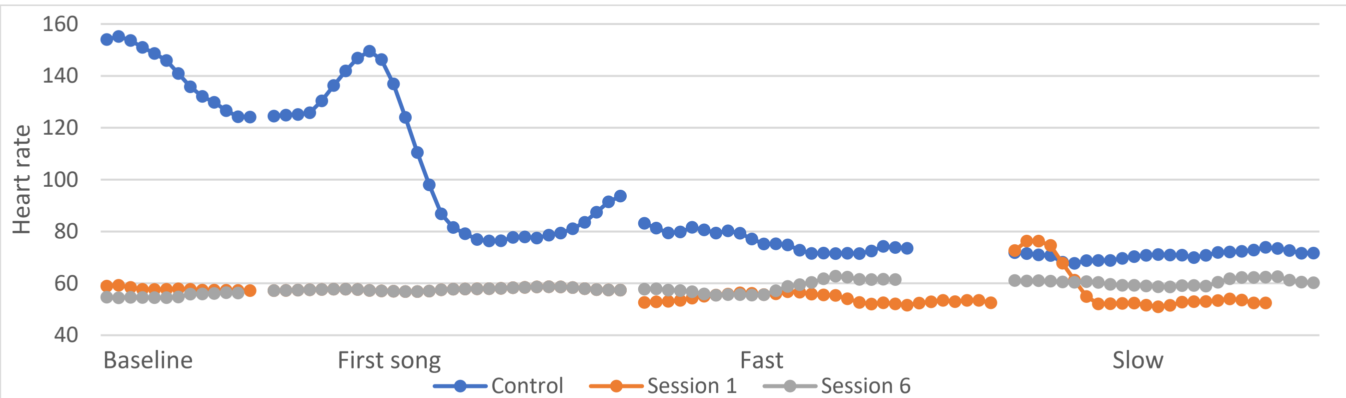


Figure 16b

P2S2 EDA during Control and Two Intervention Sessions

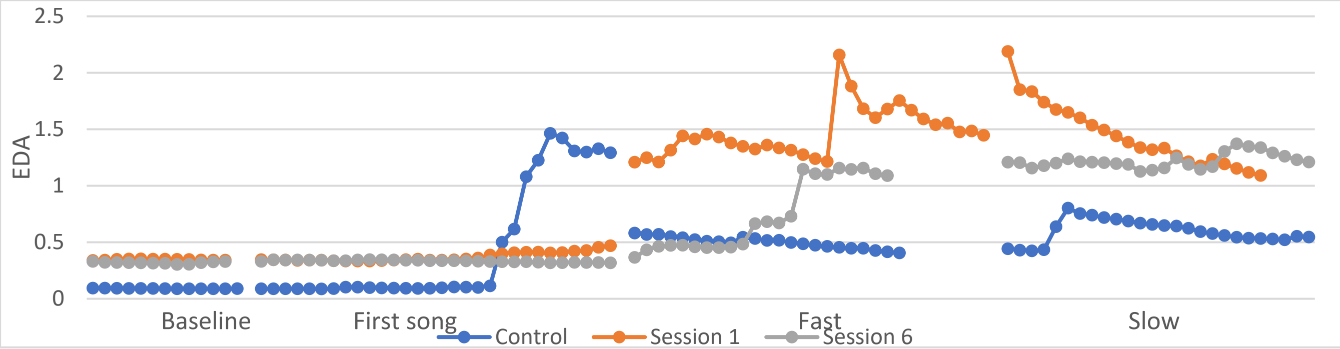


Figure 16c

P2S2 ACC during Control and Two Intervention Sessions

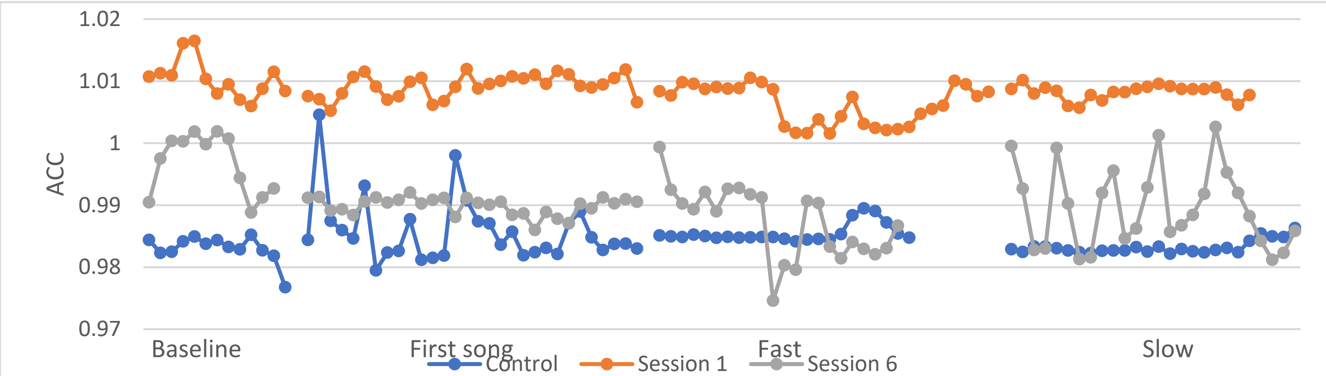


Figure 16d

P2S2 ST during Control and Two Intervention Sessions

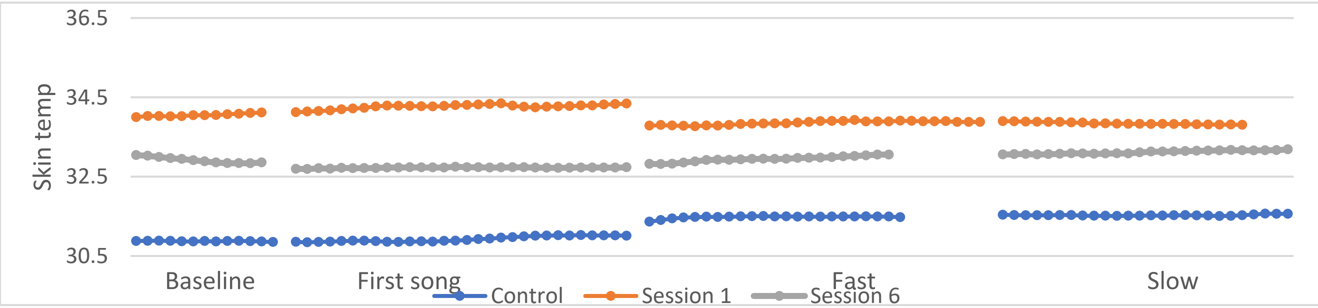


Table 28c

P2 Engagement Ratings during Fast and Slow Music of Control and Intervention Sessions

	Control		Session 1		Session 6	
	Fast	Slow	Fast	Slow	Fast	Slow
Total song length	225s	252s	335s	214s	214s	255s
Positive engagement	0 (0%)	0 (0%)	0 (0%)	0 (0%)	307 (24%)	288 (19%)
Negative engagement	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Participant 3

Physiological changes within the session. In the control session, only EDA was significantly higher during the first song compared to baseline. HR and EDA were higher during session 1, whilst ST was lower. EDA and ST were higher during session 6 whilst HR was lower. These mixed results do not support H5.

Physiolgiocal responses differed more during fast and slow music during the control session. HR and movement were significantly higher during fast music, whilst EDA and ST were higher during the slow music. EDA was also significantly higher during the slow music of session 1, partially supporting H6. ST was higher during the fast music of session 1 and the slow music of session 6.

Engagement. P3S2 tapped her toe intermittently throughout both types of music in the control session. She was alert, looking towards the laptop playing the music and spoke to a facilitator during the slower music. In session 1 she played an instrument throughout and appeared engaged but seemed briefly irritated during the faster music. In session 6 she was particularly animated during the fast music, spoke to a staff member and played her instrument. She tapped her foot during the slow music.

H7 was not supported by these results as there was little difference between the engagement during different styles of music and there were mixed physiological responses. However higher movement and lower ST was present during the faster music of the control and session 6 along with marginally higher rated levels of engagement.

Table 29a

P3S2 Mean and Standard Deviation of Physiological Responses

Measure	Session	Baseline		First song		Fast		Slow	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	Control	71.48	2.77	72.05	3.55	76.94	2.61	70.54	6.14
	1	86.68	15.25	115.81	9.84	95.22	10.48	88.00	7.39
	6	139.11	10.22	77.26	8.53	90.61	19.05	101.36	8.99
EDA	Control	0.003	0.002	0.448	0.531	0.061	0.006	0.091	0.005
	1	0.064	0.016	0.087	0.017	0.041	0.001	1.447	0.279
	6	0.087	0.027	0.126	0.008	0.080	0.009	0.100	0.034
ACC	Control	0.991	0.003	0.992	0.003	1.000	0.004	0.993	0.002
	1	0.999	0.012	0.999	0.004	1.015	0.013	1.008	0.016
	6	1.002	0.002	0.9979	0.001	1.0449	0.028	0.9997	0.001
Temp	Control	29.25	0.05	29.26	0.11	29.42	0.16	30.00	0.20
	1	30.52	0.10	29.94	0.35	30.40	0.14	30.29	0.09
	6	31.2495	0.30	31.548	0.14	31.2424	0.13	31.562	0.22

Table 29b

P3S2 Significance Values Comparing Physiological Responses

Measure	Session	Baseline – first song		Fast - slow	
		Rho	p	Rho	p
HR	Control	0.18	.121	-0.45	.001**
	Session 1	0.75	.0001**	-0.32	.004
	Session 6	-0.78	.0001**	0.45	.002
EDA	Control	0.80	.0001**	0.85	.0001**
	Session 1	0.55	.0001**	0.86	.0001**
	Session 6	0.68	.0001**	0.27	.039*
ACC	Control	0.04	.399	-0.78	.0001**
	Session 1	0.29	.028*	-0.32	.012
	Session 6	-0.70	.0001**	-0.81	.0001**
Temp	Control	-0.05	.392	0.85	.0001**
	Session 1	-0.78	.0001**	-0.43	.0001**
	Session 6	0.49	.0001**	0.76	.0001**

* P < .05

** P < .0007 Bonferroni correction

Figure 17a

P3S2 Heart Rate During Control and Two Intervention Sessions

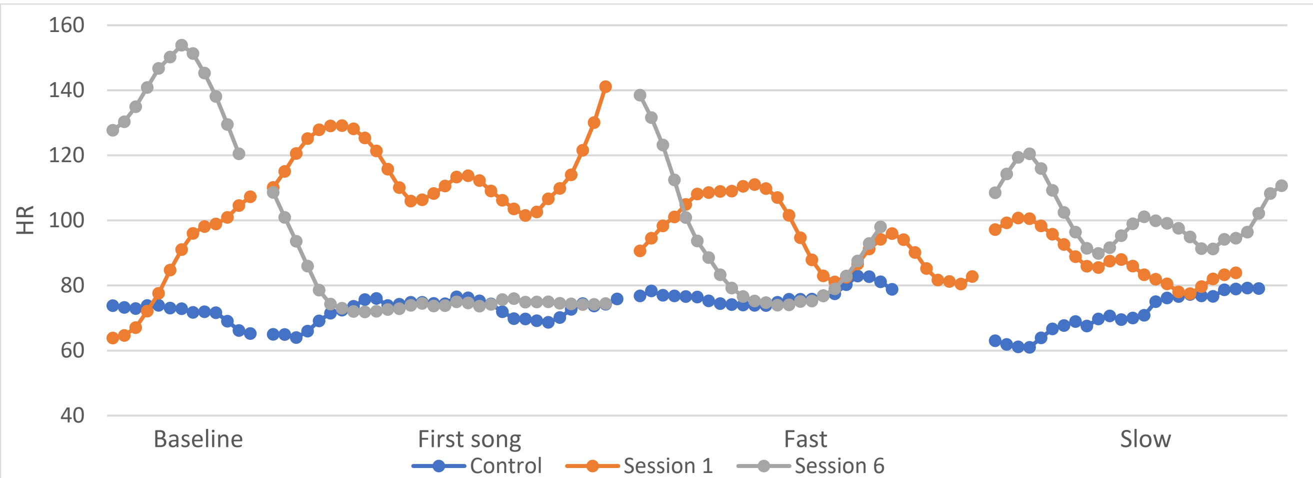


Figure 17b

P3S2 EDA During Control and Two Intervention Sessions

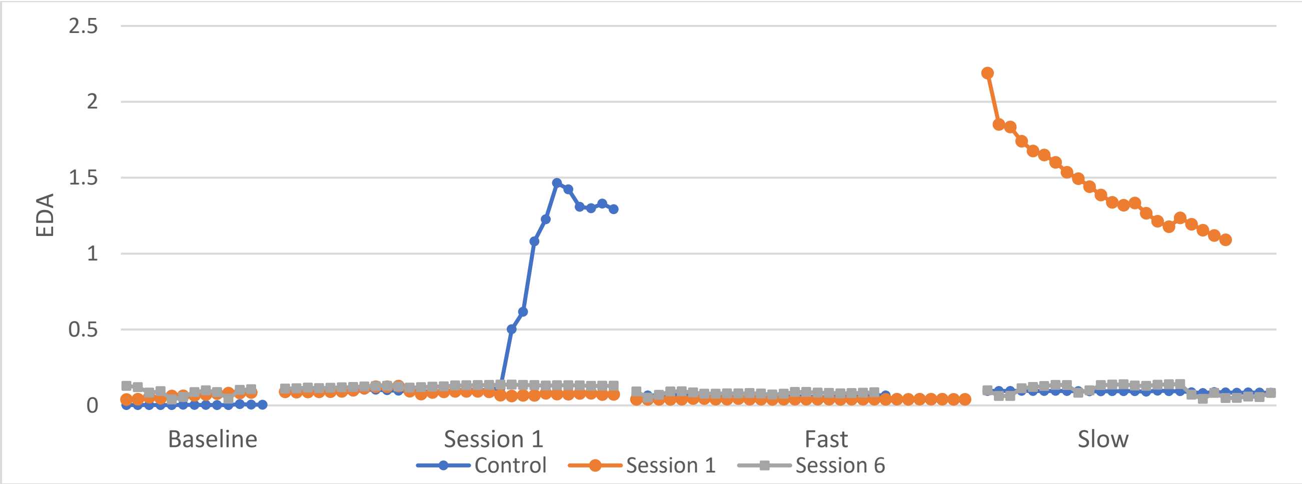


Figure 17c

P3S2 ACC During Control and Two Intervention Sessions

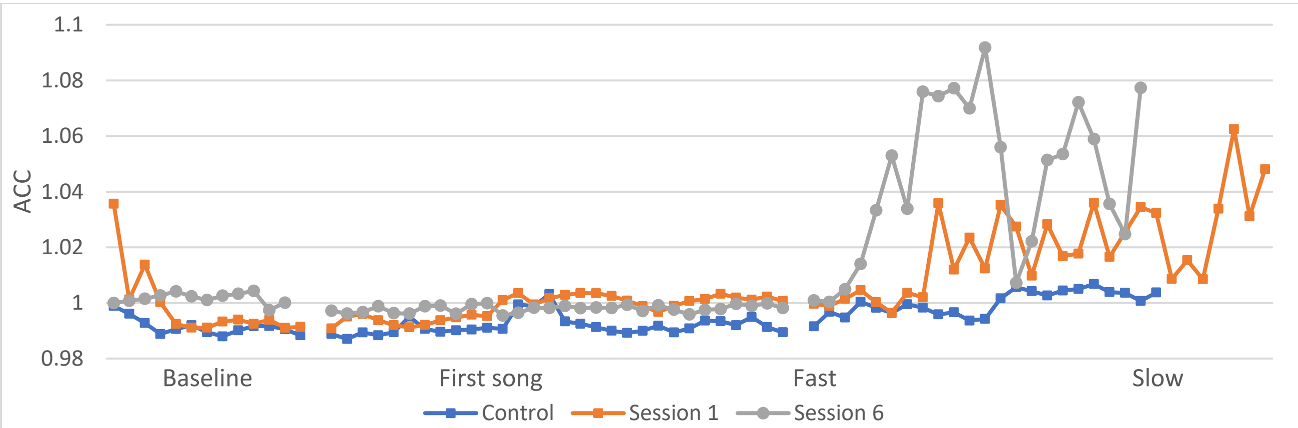


Figure 17d

P3S2 ST During Control and Two Intervention Sessions

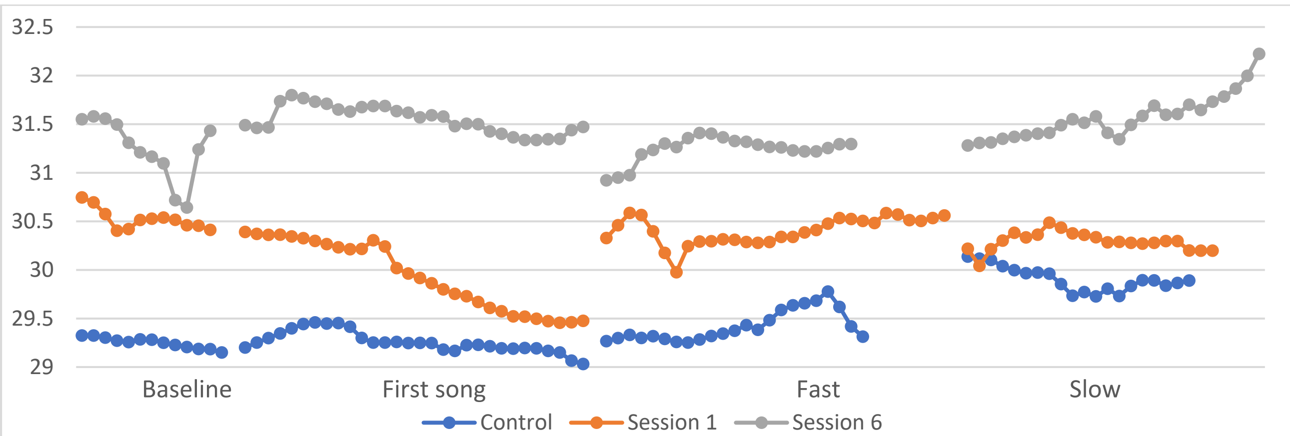


Table 29c

P3S2 Engagement Ratings of P1 During Fast and Slow Music of Control and Intervention Sessions

	Control		Session 1		Session 6	
	Fast	Slow	Fast	Slow	Fast	Slow
Total song length	225s	252s	335s	214s	214s	255s
Positive engagement	317 (23%)	279 (18%)	675 (34%)	454 (35%)	446 (35%)	462 (30%)
Negative engagement	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Participant 4

Physiological changes within the session. HR was significantly lower and ST was significantly higher than baseline during the control session. H5 was partially supported by EDA, which was significantly higher during the first song of both session 1 and 6. There were no other significant differences.

Different physiological measures were significantly different when comparing fast and slow music, therefore H6 was partially supported. EDA and ST were both significantly higher during the slow music of the control and both intervention sessions. ST was significantly higher during the fast music of both intervention sessions, along with HR in session 1 and movement in session 6.

Engagement. P4S2 was alert, tapping his foot and moving his knee to the music during both songs of session 1 and session 6, although not physically playing or touching instruments. During the fast music of session 1 and 6 he spoke to a facilitator and was engaging in eye contact. H7 was not supported by the visible engagement, as physiological responses appeared higher during the slower music, however engagement was very similar, and he experienced more interaction during the faster music.

Table 30a

P4S2 Mean and Standard Deviation of Physiological Responses

Measure	Session	Baseline		First song		Fast		Slow	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	Control	132.41	28.21	72.06	3.55	61.86	2.34	61.01	1.15
	1	64.07	3.11	67.03	9.14	60.25	0.43	61.42	1.34
	6	75.88	2.40	75.10	8.92	64.61	4.30	72.11	9.79
EDA	Control	0.334	0.470	0.214	0.037	0.216	0.014	0.319	0.049
	1	0.265	0.004	0.278	0.009	0.189	0.009	1.447	0.279
	6	0.328	0.088	0.495	0.147	0.722	0.180	0.903	0.106
ACC	Control	0.971	0.003	0.972	0.003	0.972	0.004	0.972	0.002
	1	No data		No data		No data		No data	
	6	1.014	0.007	1.017	0.006	1.045	0.028	1.002	0.004
Temp	Control	28.56	1.58	30.77	0.12	30.72	0.11	31.38	0.05
	1	31.17	0.03	31.21	0.06	31.10	0.04	31.19	0.05
	6	33.91	0.06	33.89	0.08	33.82	0.09	33.92	0.06

Table 30b

P4S4 Significance Values Comparing Physiological Responses

Measure	Session	Baseline – first song		Fast - slow	
		Rho	*p*	*Rho*	*p*
HR	Control	-0.80	.0001**	-0.12	.214
	Session 1	0.03	.424	0.41	.0001**
	Session 6	-0.04	.438	0.43	.001*
EDA	Control	0.24	.049*	0.80	.0001**
	Session 1	0.68	.0001**	0.86	.0001**
	Session 6	0.58	.0001**	0.56	.0001**
ACC	Control	0.18	.116	0.15	.149
	Session 1	No data	No data	No data	No data
	Session 6	0.28	.033*	-0.72	.0001**
Temp	Control	0.78	.0001**	0.86	.0001**
	Session 1	0.30	.094	0.74	.0001**
	Session 6	-0.24	.066	0.50	.0001**

Figure 18a

P4S2 Heart Rate During Control and Two Intervention Sessions

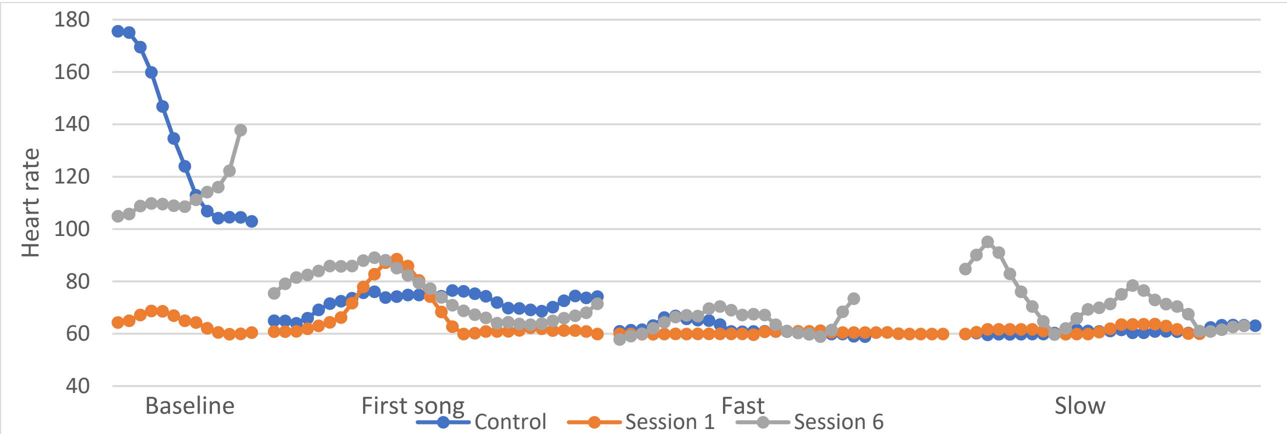


Figure 18b

P4S2 EDA During Control and Two Intervention Sessions

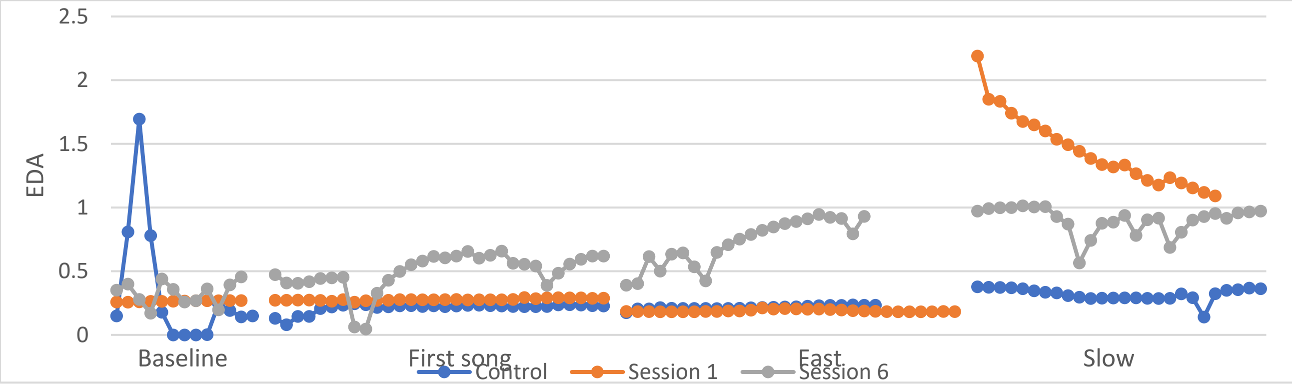


Figure 18c

P4S2 ACC During Control and Two Intervention Sessions

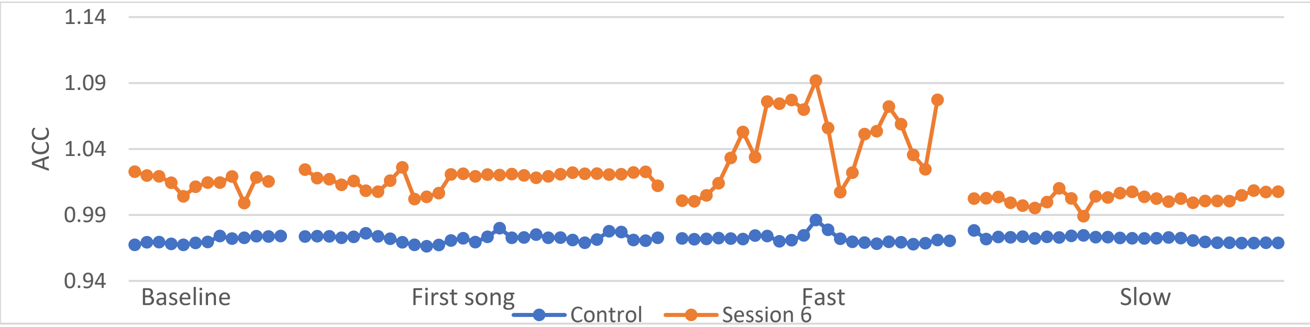
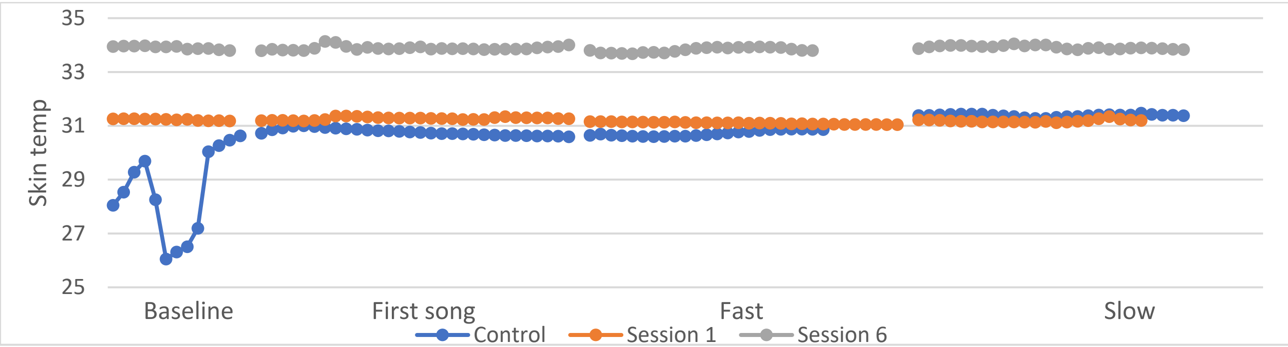


Figure 18d

P4S2 ST During Control and Two Intervention Sessions



Participant 5

Physiological changes within the session. In partial support of H5, HR and ST were significantly higher during the first song of the control session. EDA was significantly higher, and HR was significantly lower during the first song of session 1. ST was higher during the first song of session 6.

Consistent with H6, physiological responses differed during fast and slow music, however the direction of the difference was inconsistent. For example, ST was significantly higher during the slow music of the control, and significantly higher during the fast music of the intervention sessions. HR was highest during the fast music of the control and slowest music of the intervention sessions.

Engagement. In the fast song of session 1, P5S2 was sung to using her name and encouraged to play a xylophone. During the slow music she touched an instrument on her lap intermittently. P5S2 had her eyes closed during both styles of music in session 6. Although P5 appeared more engaged during the fast music of session 1, there were higher responses during the slow music therefore this does not support H7. In session 6 there was little difference between the physiological responses and she had her eyes closed throughout.

Table 31a

P5S2 Mean and Standard Deviation of Physiological Responses

Measure	Session	Baseline		First song		Fast		Slow	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR	Control	98.37	8.46	126.81	14.97	104.27	1.50	67.98	3.65
	1	62.43	2.25	59.11	0.93	67.80	5.92	77.9072	0.59
	6	113.15	8.70	110.79	47.13	67.76	9.47	89.36	23.45
EDA	Control	0.0314	0.001	0.0315	0.001	0.040	0.001	0.044	0.002
	1	0.105	0.001	0.108	0.002	0.136	0.002	1.447	0.279
	6	0.066	0.002	0.0373	0.018	0.0393	0.010	0.0310	0.006
ACC	Control	0.970	8.882	0.975	0.008	0.984	0.001	0.980	0.003
	1	0.984	0.003	0.980	0.006	0.984	0.003	0.986	0.006
	6	0.983	0.003	0.984	0.003	1.011	0.008	0.987	0.004
Temp	Control	27.23	0.03	27.41	0.03	27.26	0.01	27.41	0.05
	1	30.01	0.06	29.96	0.05	29.56	0.07	29.48	0.07
	6	30.91	0.15	31.35	0.36	31.96	0.05	32.17	0.09

Table 31b

P5S2 Significance Values Comparing Physiological Responses

Measure	Session	Baseline – first song		Fast - slow	
		Rho	p	Rho	p
HR	Control	0.73	.0001**	-0.86	.0001**
	Session 1	-0.73	.0001**	0.59	.0001**
	Session 6	-0.17	.124	0.49	.0001**
EDA	Control	0.02	.456	.74	.0001**
	Session 1	0.74	.0001**	.86	.0001**
	Session 6	-0.42	.002*	-0.31	.0001**
ACC	Control	0.37	.007	-0.60	.0001**
	Session 1	-0.31	.019*	0.23	.054
	Session 6	0.07	.33	-0.86	.0001**
Temp	Control	0.80	.0001**	0.86	.0001**
	Session 1	-0.33	.025*	-0.47	.0001**
	Session 6	0.46	.0001**	0.81	.0001**

Figure 19a

P5S2 Heart Rate During Control and Two Intervention Sessions

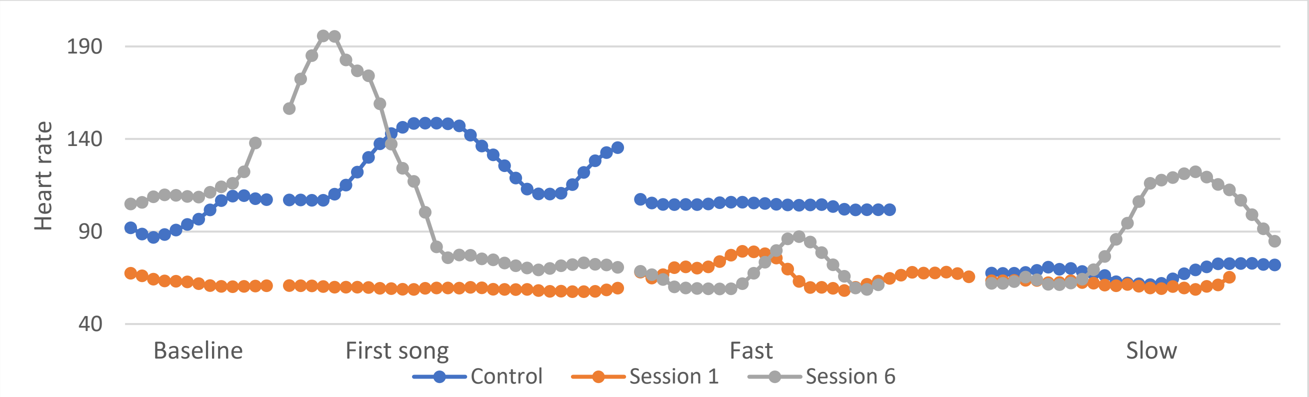


Figure 19b

P5S2 EDA During Control and Two Intervention Sessions

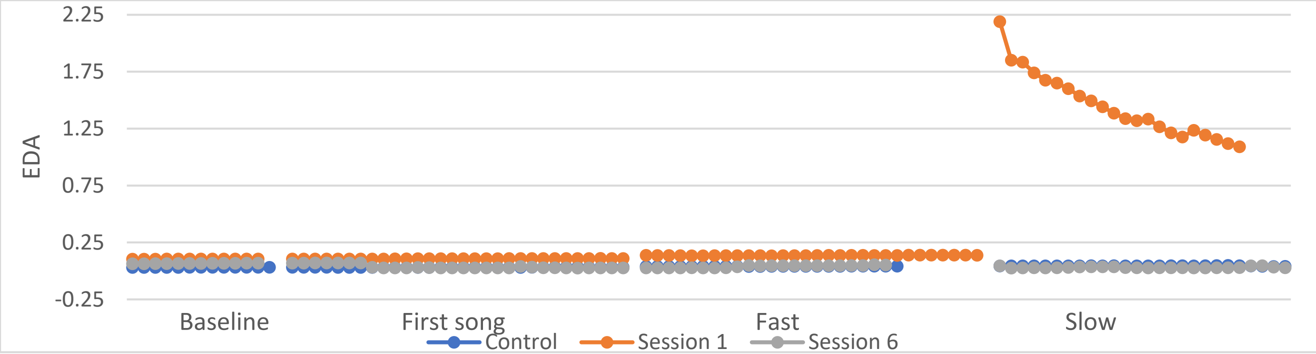


Figure 19c

P5S2 ACC During Control and Two Intervention Sessions

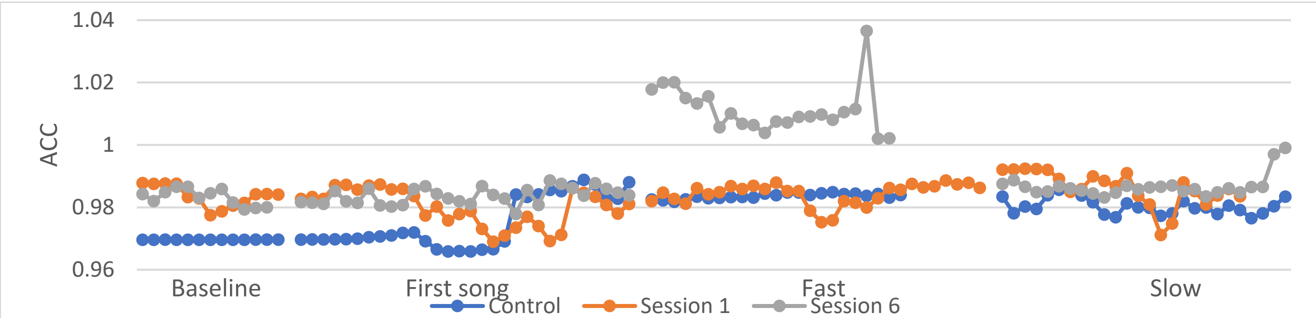
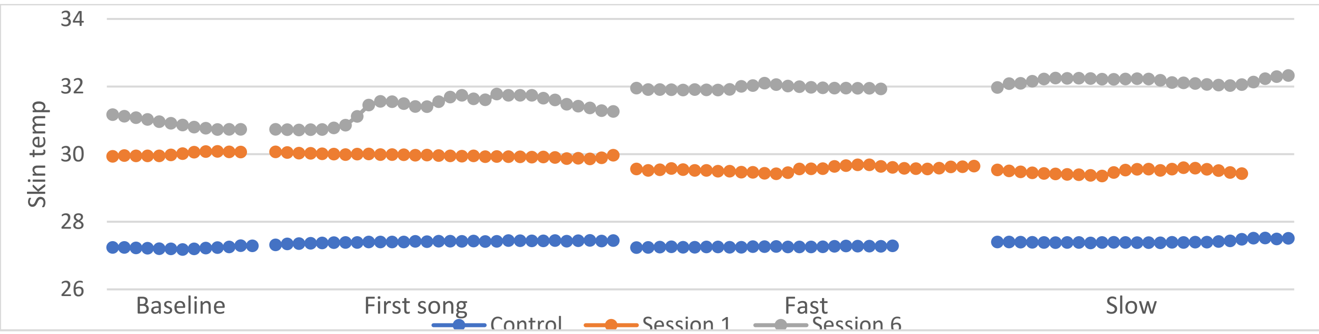


Figure 19d

P5S2 ST During Control and Two Intervention Sessions



Participant 6

Physiological changes within the session. During the control session, EDA and ST were significantly higher during the first song, however HR and movement were significantly lower. EDA and ST were higher during the first song of session 1, however HR was significantly lower during the first song of session 6, therefore H5 was not supported.

EDA was significantly higher during the slow music in the control and both intervention sessions. ST was significantly higher during the fast music of session 1 and HR was significantly higher during the fast music of session 6 therefore H6 was partially supported.

Engagement. P6S2 was still and did not interact with instruments during either style of music in session 1. He was more alert during the fast music but closed his eyes towards the end. During the slow music he had instruments being played either side of him and closed his eyes intermittently. He was more engaged in session 6, being encouraged to play an instrument during the fast music and being sung to during the slow. P6's HR was higher when encouraged to play an instrument during session 6, however EDA was significantly higher during slow music despite lower visible engagement therefore H7 was not supported.

Table 32a

P6S2 Mean and Standard Deviation of Physiological Responses

Measure	Session	Baseline		First song		Fast		Slow	
		M	SD	M	SD	M	SD	M	SD
HR	Control	71.48	2.77	60.04	2.51	57.89	2.18	60.70	4.29
	1	161.89	5.64	170.15	10.64	85.13	16.98	77.91	9.27
	6	177.04	13.27	101.91	16.53	145.66	7.16	126.67	11.51
EDA	Control	0.081	0.001	0.085	0.002	0.108	0.001	0.126	0.002
	1	0.182	0.001	0.186	0.002	0.228	0.001	1.447	0.279
	6	0.019	0.0003	0.021	0.006	0.061	0.004	0.077	0.006
ACC	Control	0.986	0.002	0.982	0.002	0.985	0.002	0.987	0.003
	1	0.995	0.001	0.994	0.002	1.011	0.002	1.007	0.006
	6	1.005	0.010	0.993	0.015	0.993	0.003	0.99521	0.002
Temp	Control	27.86	0.01	27.88	0.01	27.88	0.005	27.919	0.013
	1	29.71	0.02	29.82	0.03	30.28	0.044	30.224	0.013
	6	27.57	0.28	27.34	0.41	27.63	0.02	27.65	0.02

Table 32b

P6S2 Significance Values Comparing Physiological Responses

Measure	Session	Baseline – first song		Fast - slow	
		Rho	p	Rho	p
HR	Control	-0.80	.0001**	0.30	.016*
	Session 1	0.39	.004*	-0.10	.233
	Session 6	-0.78	.0001**	-0.68	.0001**
EDA	Control	0.80	.0001**	0.86	.0001**
	Session 1	0.77	.0001**	0.86	.0001**
	Session 6	0.40	.007	0.86	.0001**
ACC	Control	-0.66	.0001**	.27	.041*
	Session 1	-0.30	.037*	-0.33	.014*
	Session 6	-0.40	.005	0.32	.015*
Temp	Control	0.62	.001**	0.87	.0001*
	Session 1	0.78	.0001**	-0.75	.0001**
	Session 6	-0.32	.021*	0.43	.001*

M

Figure 20a

P6S2 Heart Rate During Control and Two Intervention Sessions

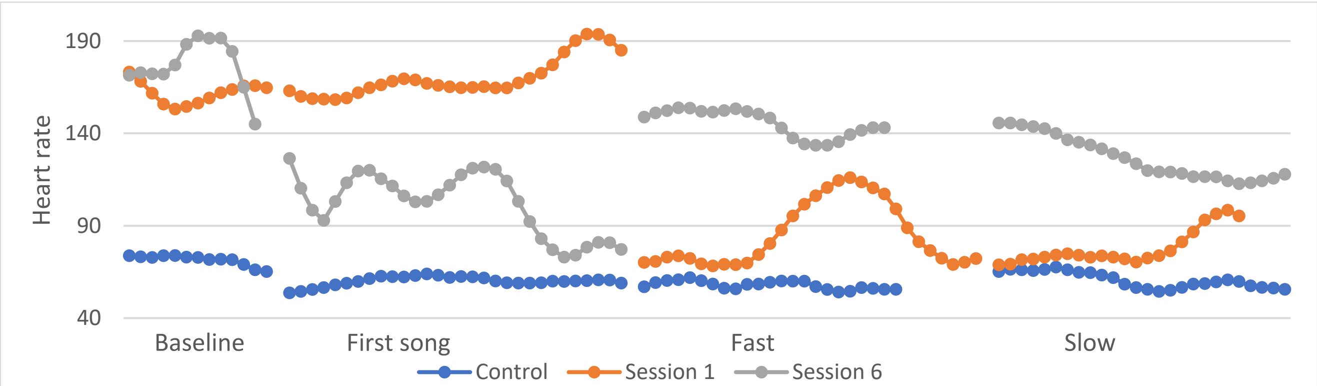


Figure 20b

P6S2 EDA During Control and Two Intervention Sessions

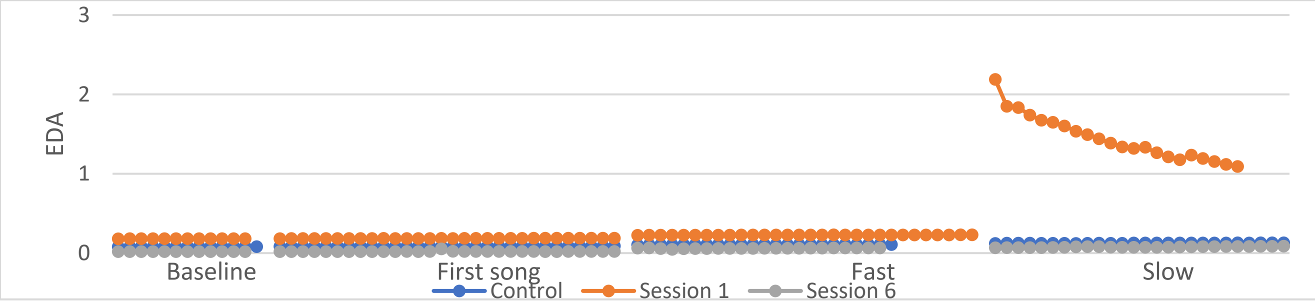


Figure 20c

P6S2 ACC During Control and Two Intervention Sessions

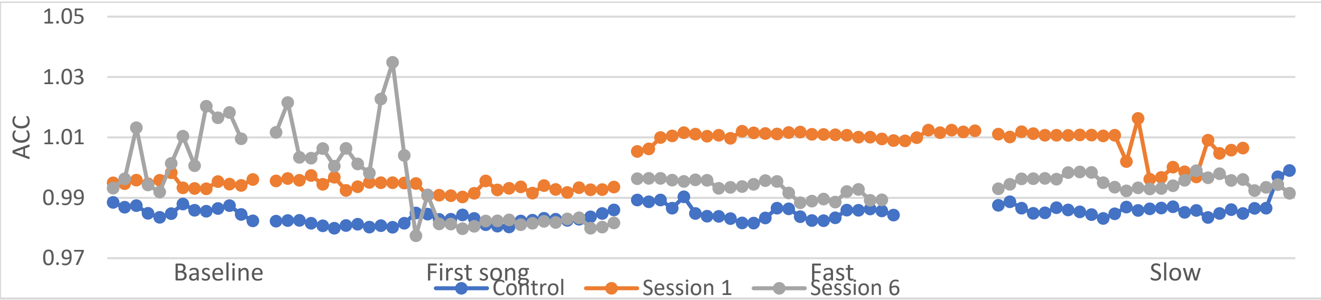
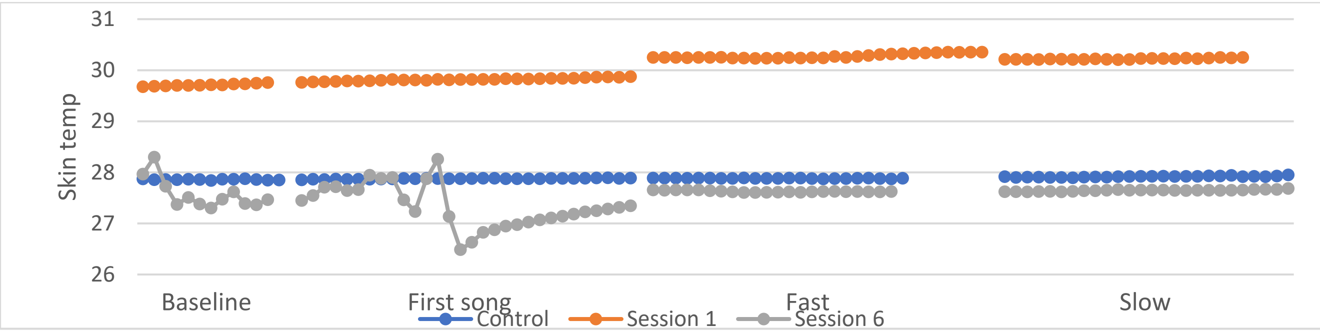


Figure 20d

P6S2 ST During Control and Two Intervention Sessions



Summary of individual case studies

Physiological changes within the session. H5 was partially supported by an increase in some physiological measures during the first song compared to baseline, particularly EDA and ST. EDA was significantly higher during the first song for three participants of the control, five during session 1, and four during session six. ST was significantly higher for four participants during the first session, two of which also showed significantly higher EDA and significantly lower HR (P1S2, P6S2). EDA and ST were significantly higher for P6S2 in both the control and session 1, however there was no significant difference in session 6, suggesting changes as the intervention progresses.

Table 33

Significance Tests for All Participants Comparing Physiological Responses during Baseline to the First Song in All Sessions

Session		P1	P2	P3	P4	P5	P6
HR	**Control**	Dark red	Light green	Yellow	Dark red	Dark green	Dark red
	1	Red	Yellow	Dark green	Yellow	Dark red	Light green
	6	Yellow	Light green	Dark red	Yellow	Yellow	Dark red
EDA	**Control**	Dark green	Light green	Dark green	Light green	Yellow	Dark green
	1	Dark green	Yellow	Dark green	Dark green	Dark green	Dark green
	6	Dark green	Dark green	Dark green	Dark green	Red	Yellow
ACC	**Control**	Dark green	Yellow	Yellow	Yellow	Yellow	Dark red
	1	Yellow	Yellow	Light green	**N/A**	Red	Red
	6	Red	Yellow	Dark red	Light green	Yellow	Yellow
ST	**Control**	Dark green	Yellow	Yellow	Dark green	Dark green	Dark green
	1	Dark red	Dark green	Dark red	Yellow	Red	Dark green
	6	Dark green	Light green	Dark green	Yellow	Dark green	Red

[Dark green] - Significantly higher during the first song after Bonferroni correction

[Light green] - Significantly higher during the first song ($p < 0.05$)

[Yellow] - No significant difference between before and during the first song

[Red] – Significantly lower during the first song than baseline ($p < 0.05$)

[Dark red] - Significantly lower during the first song after Bonferroni correction

H5 was not supported by changes in HR. Instead, more participants showed a significantly lower HR during the first song, particularly in the control session. This may reflect the relaxing impact of the music, particularly during the control which is less interactive. There were few significant differences in movement.

There were conflicting responses that raised questions about how the physiological measures relate to each other; for example the EDA of P1S2 was significantly higher across all three sessions, whilst ST was significantly higher in the control and session 6 but significantly lower in session 1.

Physiological changes related to musical style. Physiological responses were often significantly different during different styles of music in support of H6. However, there were mixed results regarding which response was higher during which style of music. Overall, there were more significantly higher responses during slow music than fast. EDA was significantly higher during the slow music for five participants in the control session, four in the first session and three participants in sessions 6. EDA was only robustly significantly higher during the faster music in one instance. Although ST was higher during the slow music for four participants in the control session and five in session six, ST was also higher during the fast music for four participants in session 1. HR results were mixed, with little differences found in HR in either intervention session. There were also fewer differences in movement, however there were more instances of significantly more movement during fast music than slow. There were more significant differences in music during the control session, perhaps due to the lack of other variables that may affect physiological responses, such as interaction and instruments.

Table 34

Significance Tests for All Participants Comparing Physiological Responses During Fast and Slow Music in All Sessions

Session		P1	P2	P3	P4	P5	P6
HR	**Control**	[dark blue]	[orange]	[orange]		[orange]	[light blue]
	1	[orange]			[dark blue]	[dark blue]	
	6	[light blue]	[light blue]		[light blue]	[dark blue]	[orange]
EDA	**Control**	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[dark blue]
	1	[orange]		[dark blue]	[dark blue]	[dark blue]	[dark blue]
	6	[yellow]	[dark blue]	[light blue]	[dark blue]	[orange]	[dark blue]
ACC	**Control**	[dark blue]	[orange]	[orange]		[orange]	[light blue]
	1				**N/A**		[yellow]
	HR			[orange]	[orange]	[orange]	[light blue]
ST	**Control**	[orange]	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[light blue]
	1	[orange]		[orange]	[dark blue]	[orange]	[orange]
	6	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[light blue]

[orange] - Significantly higher during the fast music after Bonferroni correction

[yellow] - Significantly higher during the fast music ($p < 0.05$)

[white] - No significant difference between before and during the first song

[light blue] – Significantly higher during the slow music than baseline ($p < 0.05$)

[dark blue] - Significantly higher during the slow music after Bonferroni correction

Engagement. Engagement was higher in the intervention sessions than the control session, which is reflective of the interactive nature of the sessions. Although all three participants were more engaged in session 6 than the control session, only P1 and P3 showed an increase in engagement in session 1 compared to control. Physiological measures were not consistently related to engagement for any of the participants. P2S2 showed significant differences between measures during fast and slow music but no difference in engagement as he remained still throughout. This highlights that an individual may be experiencing more than appears visible to an observer.

Peaks in the data

H8 stated that peaks in physiological responses will be associated with visible engagement. Times that physiological responses were highest across the whole of each session for each participant were identified and matched to the video footage to see what was happening at the time.

Table 35

Activity During Peaks in Physiological Responses of all Participants in all Sessions

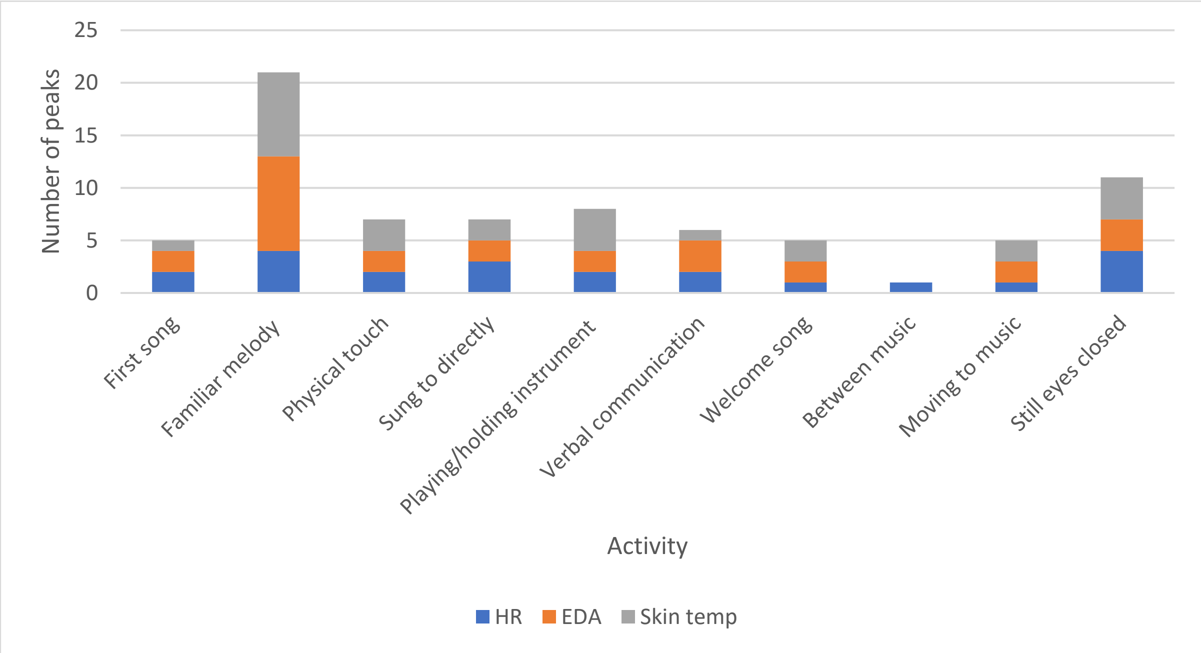
	Control	Session 1	Session 6
P1			
Heart rate	Touching hand of staff on her lap. Sits forward in chair, taps foot, gentle music playing	Facilitator uses participants name and hands her an instrument	Same melody as first song, flute is being played next to her
EDA	Just before increase highest skin temp scores, final song of the session, tapping leg	Being directly sung to as part of the welcome song by two facilitators	Towards end of welcome song, staff member is holding hand and swaying
ST	The final melody playing (similar to first song), rubbing leg, leans to speak to staff	First song, sitting very still but visually alert, turns head to watch facilitator play flute	Leaning forward, holding instrument, tapping hand, same melody as first song
P2			
Heart rate	One minute in to the first piece of music being played. Visually alert looking around	Sitting still, facilitator is next to him playing a xylophone, sharp noise, no visual response	Shaking an instrument intently with support from facilitator
EDA	Towards the end of the first song, visually alert, looking around the room	During the second half of the welcome song	Playing a percussion instrument with a beater, clarinet and harp being played near

ST	Beginning of final song which is similar melody to first song. Sitting very still in chair	Facilitator is next to him singing the welcome song	During final song, same melody as first song, sitting still, opens his eyes intermittently
P3			
Heart rate	Energetic song (second to last) had just finished, had been tapping her feet, starts speaking to facilitator	Towards the end of the first song, tapping foot visually alert	Handed an instrument for the first time in session, tapping foot and using instrument, appears alert
EDA	About 2/3 through the session, very alert, tapping foot leans forward in chair and speaks to facilitator	When the first song melody is played again at the end of the session	Being sung to directly including her name 'young at heart', flute played in front of her
ST	Start of the final song which has a similar melody to the first song sitting still	Between songs holding an instrument up, visually alert	Being sung to directly including her name 'young at heart', flute played in front of her
P4			
Heart rate	First song	Tapping foot and hand, flute played next to him	Welcome song, sung to directly
EDA	Tapping foot to music, same song as ST peak but later in song	Last song same melody as first song, tapping foot	Final song, tapping foot, familiar melody, drum nearby
ST	Tapping foot to fast music, visually alert	Holding instrument, flute nearby	Welcome song, tapping foot to music, sung to
P5			
Heart rate	Final song, same melody as first	Visually alert, holding instrument in lap, flute nearby	First song, familiar melody, eyes closed
EDA	Final song, same melody as first	Leaning forward holding instrument	Final song, familiar melody, looking around
ST	Still, faster music starts, staff hand on arm	First song, familiar melody	Final song, familiar melody, looking around
P6			
Heart rate	Final song, same melody as first	First song, familiar melody	Sitting still, eyes open, flute playing nearby
EDA	Final song, same melody as first	Last song, familiar melody	Final song, familiar melody, touch by staff
ST	Sitting still, percussion improvisation	Last song, familiar melody, staff holding hand	Final song, familiar melody holding instrument

* 'First song' relates to the first song in the control session which is then repeated at the beginning and the end of each session and thereafter recorded as a 'familiar melody'

Figure 21

Activity During Peaks in Physiological Data for all Participants in all Sessions



Discussion

Study 1

H1 predicted a change an increase in physiological responses during the first song of the session compared to before the session began, which was partially supported by changes in EDA and HR. All participants showed a significant increase in EDA during the first song and this was robustly significant for six of eight participants. Although EDA has been linked to different emotions associated with arousal including anticipatory excitement and fear (Kreibeg, 2010), the experience was likely to be positive in this instance considering continued voluntary participation of group members and verbal comments they made after the session. The increase in HR during the first song may be indicative of excitement (Wilheim et al., 2006) and/or a reflection of the energy required to sing (Bernadi et al. 2017).

Consistent with H2, physiological responses differed during different styles of music. In line with previous research which found increased physiological arousal in response to faster tempo music (Bernardi et al., 2006; Gomez & Danuser, 2007), HR and ST were significantly higher for more participants during energetic, faster music than during walking pace music. The high number of significant EDA results relating to different music styles is reflective of previous research which found increased EDA during emotional responses to music (Gomez & Danuser, 2004).

Study 2

Comparisons of physiological responses between sessions

There was an overall increase in EDA and movement during the first song of the intervention sessions compared to the control, supporting H3. Engagement was also higher during the fast and slow music of the intervention sessions compared to control. Previous research suggests that an increase in movement may indicate increased engagement (Perugia et al., 2018) and reduced depression or apathy (David et al., 2010). Increased EDA whilst listening to music in healthy adults has been linked to pleasure (Salimpoor et al., 2009); it is possible that the introduction of live instruments enhanced interest and enjoyment. The increase in engagement is reflective of the interactive nature of the intervention sessions, during which participants are encouraged to play instruments. Perhaps reflective of previous findings that HR is difficult to interpret due variety of potentially influential factors (Wilheim, 2006), the HR results were mixed and did not support H3.

Overall, physiological responses were significantly higher during the first song of session 1 than session 6, therefore H4 was not supported. This was particularly evident in HR and EDA, suggesting physiological responses diminish as the intervention becomes less novel, or participants may have become or more comfortable with the group and process

(Clare et al., 2020). There were fewer differences in movement, which may be expected as both intervention sessions encourage interaction.

Physiological responses within sessions

EDA and ST were higher overall during the first song than baseline. This was particularly evident in EDA which is reflective of study 1 and associated with increased pleasure (Salimpoor et al., 2009). Increases in ST have been associated with music eliciting calm and positive emotions in healthy adults (McFarland, 1985). EDA increased during the control session for four participants, suggesting listening to music alone is also beneficial, however there were more significantly robust increases in EDA during the intervention sessions. In contrast to study 1, H5 was not supported by HR, which was often lower during the first song of the session than baseline. A reduction in HR has been related to improved mood (Raglio et al., 2010) and may be reflective of the relaxing nature of the intervention sessions in contrast to the energy required to sing in Study 1.

Physiological responses were predicted to differ depending on the style of music playing (H6) and this hypothesis was partially supported, however results were inconsistent. Overall, the case studies found more significantly higher physiological responses during slow music, particularly for EDA and ST to a lesser extent. ST results were not consistent across different sessions. Most participants ST was significantly higher during the slow music of the control and session 6, and during the faster music of session 1. This suggests other factors aside from musical style may be having an influence. In contrast to Study 1 and previous research that found an increase in HR during different songs (Norberg et al., 2003), HR results were inconsistent. There were more significant differences between fast and slow music during the control than the intervention sessions. Musical style may have less influence during the interactive sessions as there are more variables that may have an impact (e.g. whether they were playing an instrument or one-on-one interactions).

H7 proposed that changes in physiological responses will be associated with rated and visible engagement. Engagement is a way of monitoring how helpful an activity is for a PWD and was described by Perugia et al., (2018) as the "psychological state of wellbeing, enjoyment and active involvement that is triggered by meaningful activities" (p 112). There was little difference between rated engagement during different types of music, which was also reflected by mixed physiological responses. Previous research has linked changes in EDA to engagement due to changes during episodes of excitement and attention (Andreassi, 2013; Perugia et al., 2017). Although physiological responses reflected rated engagement at times, this was not consistent enough to support H7. P2S2 showed a peak in ST, EDA and movement in session 1 despite not appearing engaged. This suggests a person may be experiencing more than it appears which is useful information for encouraging carers to continue to offer activities regardless of whether the PWD appears disengaged.

Peaks in the data

Activity during peaks in the data partially supported H8. Activities related to visible engagement were present, including physical touch or interacting with an instrument, however the most common activity during the highest physiological responses was the presence of a familiar melody. In line with the notion of "inclusion" (Kitwood, 1997), responses were also high when participants were being sung to using their name. These findings indicate that individual interactions fostering elements of personhood such as identity/inclusion and occupation (playing instruments) create changes in physiological responses that may be related to enjoyment and stimulation (McFarland, 1985; Salimpoor et al., 2009). Having a role in creating music may also have met Nolan et al., (2004)'s senses of "achievement" and "purpose".

ST and EDA peaked at similar times, including listening to familiar melodies, physical touch or holding an instrument. Activity during increased HR was more varied, yet also included familiar music and being sung to. In line with findings related to H7, peaks also occurred when participants appeared disengaged with their eyes closed.

Strengths and limitations

A multiple-case study design allows analysis of data within and across different case studies (Yin, 2003) and evidence formed from studies of this nature has been considered strong and reliable (Baxter & Jack, 2008). Yin emphasized the importance of four factors; construct validity, internal validity, external validity and reliability (Yin, 2003) and these factors will be considered below.

Yin suggested construct validity is obtained by multiple sources of evidence, which has been more effectively achieved in study 2 by utilising video footage and an external rater. The use of established SMA to detect patterns in physiological responses enhances the internal validity of this research (Borckardt et al., 2008). Using responses of the ANS can be challenging due potential external influences such as movement, interactions and enjoyment (Kim & Andre, 2008) and the high degree of variation between individuals and over time (Jaimovich et al., 2012). Using video data along with the physiological responses strengthens this research as it has allowed a more detailed understanding of how a person's presentation may relate to the measures on an individual basis.

The statistics used did not correct for covariates which may be considered a threat to internal validity. EDA for example, may be impacted by movement, however there was minimal difference in movement in some of the conditions that saw changes in EDA. It would also have been beneficial to consider whether participants were on any sedating medications and when these are taken as this is likely to have implications for physiological responses.

Case studies are generally considered to have low external validity (Jacobsen, 2002). Collating multiple case studies may limit the time that can be spent on each individual observation, yet increase representativeness (Gerring, 2004). The naturalistic setting of this study meant that participants were not randomly selected, and all participants were either white British or white European. These factors in addition to the small number of cases make it difficult to extrapolate findings to a wider population. In study 1, a number of confounding variables may have been accounted for as the group had been running for two months so participants would be familiar with the group and environment, however study 2 was a new intervention and they would have only met the facilitators at the control session. It is therefore difficult to attribute physiological changes to the activity alone and not the novel group setting.

Due to the variability in the data, it would have been beneficial to observe interactions during the troughs in addition to during the peaks. Without observing behaviour during the troughs for an absence of interactions/familiar music, it is difficult to conclude that the increase in responses is related directly to these events.

Clinical implications

In line with previous research (Livingston et a., 2014) these two studies indicate that music-based activities are beneficial for people with dementia, as there were increases in physiology associated with enjoyment and engagement. However, these outcomes should be considered tentatively due to the methodological limitations of the studies. Peaks in the physiological data when an individual does not appear engaged highlights the importance for interventions to increase meaningful interactions with people in the later stages of dementia even if they do not appear visibly engaged. Following Kitwood's principles (e.g. 'inclusion' by singing directly) appeared to lead to increases in physiological response. Non-intrusive physiological measurement may be a beneficial way of gathering more information about the most engaging aspects of an activity and inform the development of future interventions.

Future research

Differences between intervention sessions suggest that following a community group intervention longitudinally may be beneficial to observe changes in physiological responses over time. Future multiple-case study research should place emphasis on construct validity (Yin, 2003) by collating physiological measures alongside video analysis, observations and psychometric measures when appropriate. This may provide a clearer understanding of what physiological responses may be telling us and what wellbeing and engagement mean for this population. As peaks in physiological data were associated with familiar music and playing instruments, consideration of the participant's prior musical interests and relationship with singing/playing an instrument earlier in life should be noted in future research. Larger sample sizes and looking specifically at different types of dementia will also help to further develop dementia care strategies.

Conclusions

The aim of these two linked multiple-case studies was to observe physiological responses of people at different stages of dementia during two music-based activities. During a community singing group, EDA and HR increased indicating increased arousal and enjoyment. HR and ST were higher during faster music and EDA was influenced by different musical styles.

EDA, movement and rated engagement were all higher during an interactive music group compared to the control session. When compared to baseline, EDA and ST were higher and HR was lower during the intervention suggesting a calming, emotional response. Physiological responses peaked during familiar music, personal interactions and physical touch. Peaks also occurred at time that the individual appeared disengaged. These case studies indicate that music-based activities may increase arousal and engagement for PWD. Future research of physiological measures longitudinally and in conjunction with video-analysis and/or psychometric measures will enrich our understanding of how engagement and wellbeing interact for this population.

References

Andreassi, J. L. (2007). *Psychophysiology: Human behaviour & physiological response*. New York: Psychology Press.

Barrett, L. F. (2014). The conceptual act theory: A précis. *Emotion review*, *6*(4), 292-297. https://doi.org/10.1177/1754073914534479

Barlow, D. H., Andrasik, F., & Hersen, M. (2007). *Single case experimental designs*. London: Allyn and Bacon.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Bernardi, L., Porta, C., & Sleight, P. (2006). Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence. *Heart*, *92*(4), 445-452. http://dx.doi.org/10.1136/hrt.2005.06460z0

Bernardi, N. F., Snow, S., Peretz, I., Perez, H. O., Sabet-Kassouf, N., & Lehmann, A. (2017). Cardiorespiratory optimization during improvised singing and toning. *Scientific reports*, *7*(1), 1-8. https://doi.org/10.1038/s41598-017-07171-2

Bourne, P., Camic, P. M., Crutch, S., Hulbert, S., Firth, N., & Harding, E. (2019). Using psychological and physiological measures in arts-based activities in a community sample of people with a dementia and their caregivers: a feasibility and pilot study. *Journal of Aging Studies and Therapies*. Retrieved from https://sciforschenonline.org/journals/aging-studies-therapies/article-data/JAST102/JAST102.pdf

Borckardt, J. J., & Nash, M. R. (2014). Simulation modelling analysis for small sets of single-subject data collected over time. *Neuropsychological Rehabilitation*, *24*(3-4), 492-506. https://doi.org/10.1080/09602011.2014.895390

Brod, M., Stewart, A. L., Sands, L., & Walton, P. (1999). Conceptualization and measurement of quality of life in dementia: the dementia quality of life instrument (DQoL). *The Gerontologist*, *39*(1), 25-36. https://doi.org/10.1093/geront/39.1.25

Camic, P. M., Williams, C. M., & Meeten, F. (2013). Does a 'Singing Together Group' improve the quality of life of people with a dementia and their carers? A pilot evaluation study. *Dementia*, *12*(2), 157-176.

Chen, L., Zhou, S., & Bryant, J. (2007). Temporal changes in mood repair through music consumption: Effects of mood, mood salience, and individual differences. *Media Psychology*, *9*(3), 695-713. https://doi.org/10.1080/15213260701283293

Clare, A., Camic, P. M., Crutch, S. J., West, J., Harding, E., & Brotherhood, E. (2019). Using music to develop a multisensory communicative environment for people with late-stage dementia. *The Gerontologist*. 1-11. https://doi.org/10.1093/geront/gnz16

Clark, M. E., Lipe, A. W., & Bilbrey, M. (1998). Use of music to decrease aggressive behaviours in people with dementia. *Journal of Gerontological Nursing*, *24*(7), 10-17. https://doi.org/10.3928/0098-9134-19980701-05

Clark-Carter, D. (1997). *Doing quantitative psychological research: from design to report*. Psychology Press/Erlbaum (UK) Taylor & Francis.

Cooper, C., Mukadam, N., Katona, C., Lyketsos, C. G., Ames, D., Rabins, P., Engedal, Lima, Blazer, Teri, Brodaty and Livingston (2012). Systematic review of the effectiveness of non-pharmacological interventions to improve quality of life of people with dementia. *International Psychogeriatrics*, *24*(6), 856-870. https://doi.org/10.1017/S1041610211002614

Cuddy, L. L., & Duffin, J. (2005). Music, memory, and Alzheimer's disease: is music recognition spared in dementia, and how can it be assessed?. *Medical hypotheses*, *64*(2), 229-235. https://doi.org/10.1016/j.mehy.2004.09.005

David, R., Rivet, A., Robert, P. H., Mailland, V., Friedman, L., Zeitzer, J. M., & Yesavage, J. (2010). Ambulatory actigraphy correlates with apathy in mild Alzheimer's disease. *Dementia*, *9*(4), 509-516. https://doi.org/10.1177/1471301210381678

Department of Health. (2005). *Mental Capacity Act.* London: HMSO.

Edvardsson, D., Petersson, L., Sjogren, K., Lindkvist, M., & Sandman, P. O. (2014). Everyday activities for people with dementia in residential aged care: associations with person-centredness and quality of life. *International Journal of Older People Nursing*, *9*(4), 269-276. https://doi.org/10.1111/opn.12030

Gallego, M. G., & García, J. G. (2017). Music therapy and Alzheimer's disease: Cognitive, psychological, and behavioural effects. *Neurología (English Edition)*, *32*(5), 300-308. https://doi.org/10.1016/j.nrleng.2015.12.001

Gerring, J. (2004). What is a case study and what is it good for?. *American political science review*, 341-354. https://doi.org/jstor.org/stable/4145316

Getz, L. M., Marks, S., & Roy, M. (2014). The influence of stress, optimism, and music training on music uses and preferences. *Psychology of Music*, *42*(1), 71-85. https://doi.org/10.1177/0305735612456727

Gomez, P., & Danuser, B. (2004). Affective and physiological responses to environmental noises and music. *International Journal of Psychophysiology*, *53*(2), 91-103.

Gomez, P., & Danuser, B. (2007). Relationships between musical structure and psychophysiological measures of emotion. *Emotion*, *7*(2), 377. https://doi.org/10.1037/1528-3542.7.2.377

Herborn, K. A., Graves, J. L., Jerem, P., Evans, N. P., Nager, R., McCafferty, D. J., & McKeegan, D. E. (2015). ST reveals the intensity of acute stress. *Physiology & Behaviour*, *152*, 225-230. https://doi.org/10.1016/j.physbeh.2015.09.032

Hsu, M. H., Flowerdew, R., Parker, M., Fachner, J., & Odell-Miller, H. (2015). Individual music therapy for managing neuropsychiatric symptoms for people with dementia and their carers: a cluster randomised controlled feasibility study. *BMC geriatrics*, *15*(1), 84. https://doi.org/10.1186/s12877-015-0082-4

Jacobsen, D. I., & Sandin, G. (2002). *Vad, hur och varför: om metodval i företagsekonomi och andra samhällsvetenskapliga ämnen*. Studentlitteratur.

Jaimovich, J., Coghlan, N., & Knapp, R. B. (2012). Emotion in motion: A study of music and affective response. In *International Symposium on Computer Music Modeling and Retrieval* (19-43). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-41248-6_2

Jones, C., Sung, B., & Moyle, W. (2015). Assessing engagement in people with dementia: A new approach to assessment using video analysis. *Archives of psychiatric nursing*, *29*(6), 377-382. https://doi.org/10.1016/j.apnu.2015.06.019

Kitwood, T. (1997). The experience of dementia. *Aging & Mental Health*, *1*(1), 13-22. https://doi.org/10.1080/13607869757344

Kim, J., & André, E. (2008). Emotion recognition based on physiological changes in music listening. *IEEE transactions on pattern analysis and machine intelligence*, *30*(12), 2067-2083. https://doi.org/10.1109/TPAMI.2008.26

Kratz, T. (2017). The diagnosis and treatment of behavioural disorders in dementia. *Deutsches Ärzteblatt International*, *114*(26), 447-454. https://doi.org/10.3238/arztebl.2017.0447

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology*, *84*(3), 394-421. https://doi.org/10.1016/j.biopsycho.2010.03.010

Liljeström, S., Juslin, P. N., & Västfjäll, D. (2013). Experimental evidence of the roles of music choice, social context, and listener personality in emotional reactions to music. *Psychology of Music*, *41*(5), 579-599. https://doi.org/10.1177/0305735612440615

Livingston, G., Kelly, L., Lewis-Holmes, E., Baio, G., Morris, S., Patel, N., Omar, R., Katona, C., & Cooper, C. (2014). Non-pharmacological interventions for agitation in dementia: systematic review of randomised controlled trials. *The British Journal of Psychiatry*, *205*(6), 436-442. https://doi.org/10.1192/bjp.bp.113.141119

McFarland, R. A. (1985). Relationship of ST changes to the emotions accompanying music. *Biofeedback and Self-regulation*, *10*(3), 255-267.

Melander, C., Martinsson, J., & Gustafsson, S. (2017). Measuring electrodermal activity to improve the identification of agitation in individuals with dementia. *Dementia and Geriatric Cognitive Disorders*, *7*(3), 430-439. https://doi.org/10.1159/000484890

Mowrey, C., Parikh, P. J., Bharwani, G., & Bharwani, M. (2013). Application of behaviour-based ergonomics therapies to improve quality of life and reduce medication usage for

Alzheimer's/dementia residents. *American Journal of Alzheimer's Disease & Other Dementias*, *28*(1), 35-41.

National Institute for Health and Care Excellence. (2019). Dementia: assessment, management and support for people with dementia and their carers. [NICE Guideline no. NG97]. https://www.nice.org.uk/guidance/ng97

Nolan, M. R., Davies, S., Brown, J., Keady, J., & Nolan, J. (2004). Beyond 'person-centred'care: a new vision for gerontological nursing. *Journal of Clinical Nursing*, *13*, 45-53. https://doi.org/10.1111/j.1365-2702.2004.00926.x

Norberg, A., Melin, E., & Asplund, K. (2003). Reactions to music, touch and object presentation in the final stage of dementia: an exploratory study. *International Journal of Nursing Studies*, *40*(5), 473-479. https://doi.org/10.1016/S0020-7489(03)00062-2

Oka, T., Oka, K., & Hori, T. (2001). Mechanisms and mediators of psychological stress-induced rise in core temperature. *Psychosomatic Medicine*, *63*(3), 476-486. https://doi.org/10.1097/00006842-200105000-00018

Penrod, J., Yu, F., Kolanowski, A., Fick, D. M., Loeb, S. J., & Hupcey, J. E. (2007). Reframing person-centered nursing care for persons with dementia. *Research and Theory for Nursing Practice*, *21*(1), 57-72. https://doi.org/ 10.1891/rtnpij-v21i1a007

Perugia, G., Rodríguez-Martín, D., Boladeras, M. D., Mallofré, A. C., Barakova, E., & Rauterberg, M. (2017). Electrodermal activity: explorations in the psychophysiology of engagement with social robots in dementia. In *International Symposium on Robot and Human Interactive Communication* (1248-1254). https:// i.org/10.1109/ROMAN.2017.8172464

Perugia, G., Rodríguez-Martín, D., Boladeras, M. D., Mallofré, A. C., Barakova, E., & Rauterberg, M. (2018). Quantity of movement as a measure of engagement for dementia: the influence of motivational disorders. *American Journal of Alzheimer's Disease & Other Dementias®*, *33*(2), 112-121. https://doi.org/10.1177/1533317517739700

Raglio, A., Bellelli, G., Traficante, D., Gianotti, M., Ubezio, M. C., Gentile, S., Villani, D. & Trabucchi, M. (2010). Efficacy of music therapy treatment based on cycles of sessions: a randomised controlled trial. *Aging and Mental Health*, *14*(8), 900-904.https://doi.org/10.1080/13607861003713158

Särkämö, T. (2018). Music for the ageing brain: Cognitive, emotional, social, and neural benefits of musical leisure activities in stroke and dementia. *Dementia*, *17*(6), 670-685. https://doi.org/10.1177/1471301217729237

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PloS one*, *4*(10). https://doi.org/10.1371/journal.pone.0007487

Stemmler, G. (2004). Physiological processes during emotion. In *The regulation of emotion* (pp. 48-85). Hove: Psychology Press.

Suzuki, M., Kanamori, M., Nagasawa, S., Tokiko, I., & Takayuki, S. (2007). Music therapy-induced changes in behavioural evaluations, and saliva chromogranin A and immunoglobulin A concentrations in elderly patients with senile dementia. *Geriatrics & Gerontology International*, *7*(1), 61-71. https://doi.org/10.1111/j.1447-0594.2007.00374.x

Thoma, M. V., La Marca, R., Brönnimann, R., Finkel, L., Ehlert, U., & Nater, U. M. (2013). The effect of music on the human stress response. *PloS one*, *8*(8). 1-12. https://doi:10.1371/journal.pone.0070156

Thomas, G. E., Crutch, S. J. & Camic, P. M. (2018). Measuring physiological responses to the arts in people with a dementia. *International Journal of Psychophysiology*, *123*, 64-73. https://doi.org/10.1016/j.ijpsycho.2017.11.008

Van der Steen, J. T., Smaling, H. J., van der Wouden, J. C., Bruinsma, M. S., Scholten, R. J., & Vink, A. C. (2018). Music-based therapeutic interventions for people with dementia. *Cochrane Database of Systematic Reviews*, (7). https://doi.org/10.1002/14651858.CD003477.pub4

Wijsman, J., Grundlehner, B., Liu, H., Hermens, H., & Penders, J. (2011, August). Towards mental stress detection using wearable physiological sensors. *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. 1798-1801. https://doi.org/10.1109/IEMBS.2011.6090512

Wilhelm, F. H., Pfaltz, M. C., Grossman, P., & Roth, W. T. (2006). Distinguishing emotional from physical activation in ambulatory psychophysiological monitoring. *Biomedical Sciences Instrumentation*, *42*, 458-463.

Williams, C., Tappen, R., Wiese, L., Newman, D., Corbett, M., Pinos, S., Curtis, B., & Murray, B. (2016). Stress in persons with dementia: Benefits of a memory center day program. *Archives of psychiatric nursing*, *30*(5), 531-538. https://doi.org/10.1016/j.apnu.2016.04.011

Wittenberg, R., Hu, B., Jagger, C., Kingston, A., Knapp, M., Comas-Herrera, A., ... & Banerjee, S. (2020). Projections of care for older people with dementia in England:

2015 to 2040. *Age and Ageing*, *49*(2), 264-269.
https://doi.org/10.1093/ageing/afz154

World Health Organization. (2019). Risk reduction of cognitive decline and dementia: WHO guidelines. In *Risk reduction of cognitive decline and dementia: WHO guidelines* (pp. 401-401).

Yin, R. K. (2003). Designing case studies. *Qualitative Research Methods*, 359-386.

Appendix A

Mixed methods appraisal tool

Part I: Mixed Methods Appraisal Tool (MMAT), version 2018

Category of study designs	**Methodological quality criteria**	**Responses**			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?				
	S2. Do the collected data allow to address the research questions?				
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non-randomized	3.1. Are the participants representative of the target population?				
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?				
	3.3. Are there complete outcome data?				
	3.4. Are the confounders accounted for in the design and analysis?				
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?				
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
	4.3. Are the measurements appropriate?				
	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?				
	5.2. Are the different components of the study effectively integrated to answer the research question?				
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?				
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?				
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

Appendix B

Ethics letter

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Appendix C

Empatica-E4 Wristbands

Appendix D

Consent form

Consent Form for family members (2 pages)
Version 1A (28/6/17)

Participant ID: ______________

Title of Project: Understanding communication in a Music for Life group

Name of Researchers: Amy Clare, Daniel Lai, Professor Paul Camic and Professor Seb Crutch.

Please initial each box if you agree:

1. I confirm that I have read and understand the information sheet (version 1A dated 28/6/17) for the above research. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that the Music for Life group session will be video recorded for the purpose of this research. ☐

3. I also understand the video recordings may be used in possible future research and for educational purposes. ☐

4. I also understand that my family member will be asked to wear the Empatica wristband for several music sessions. I agree to them wearing it. ☐

5. If my relative had been able to give consent for this I believe they would have agreed to participate and think this is something they would have wanted. ☐

6. I understand that anonymous data from this project will be available to Canterbury Christ Church University and University College London researchers; results from this research will be submitted as part of two doctoral theses and for journal publications, and that information from the study may be used in future research projects. Individual participants will **not** be identified. We will, however, identify our community partners, Wigmore Hall and Jewish Care. ☐

Next page please →

7. I give informed consent for the participant to take part in this present project and acknowledge that the participation is voluntary and that they are free to withdraw at any time without giving any reason. [ ]

Name of Participant: ________________________________

Name of Person giving consent: ________________________

Signature: ____

Date: ____

Witness Name: _____________________________________

Witness Signature: __________________________________

Appendix E

Video Coding Incorporating Observed Emotion (VC-1OE)

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Appendix F

	Participant 1						Participant 2						Participant 3					
	Control		Session 1		Session 6		Control		Session 1		Session 6		Control		Session 1		Session 6	
Total song length	Fast 225s	Slow 252s	Fast 335s	Fast 214s	Slow 214s	Slow 255s	Fast 225s	Slow 252s	Fast 335s	Slow 214s	Fast 214s	Slow 255s	Fast 225s	Slow 252s	Fast 335s	Slow 214s	Fast 214s	Slow 255s
Positive emotions	0	20	34	25	0	0	0	2	0	0	12	5	5	23	0	0	23	0
Negative emotions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Neutral	225	232	30	189	214	255	225	250	335	214	202	250	220	202	330	214	191	255
Visually engaged	98	176	33	214	214	255	0	0	8	0	151	118	157	218	335	214	214	255
No visual engagement	127	76	0	0	0	0	0	0	29	0	0	0	68	34	0	0	0	0
Eyes closed	0	0	0	0	0	0	225	252	298	214	63	0	0	0	0	0	0	0
Positive verbal engagement	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	26	9	13
Negative verbal engagement	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
No verbal engagement	225	252	335s	214	214	255	225	252	335	214	214	255	225	217	298	199	205	242
Positive behavioural engagement	122	148	335	214	214	255	0	0	0	0	144	165	155	30	335	214	200	194
Negative behavioural engagement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

No behavioural engagement	103	104	0	0	0	0	225	252	335	214	70	90	70	222	0	0	14	61
Evidence of collective engagement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No collective engagement	225	252	335	214	214	255	225	252	335	214	214	255	225	252	335	214	214	255
Evidence of agitation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No evidence of agitation	225	252	335	214	214	255	225	252	335	214	214	255	225	252	335	214	214	255
Total positive engagement	220 (17%)	1512 (23%)	2010 (20%)	453 (35%)	418 (33%)	510 (33%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	307 (24%)	288 (19%)	317 (23%)	279 (18%)	675 (34%)	454 (35%)	446 (35%)	462 (30%)
Total negative engagement	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Appendix G

Submission guidelines for Wellcome Open Research

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