



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Research Commons

<https://researchcommons.waikato.ac.nz/>

Research Commons at the University of Waikato

Copyright Statement:

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

The thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognise the author's right to be identified as the author of the thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from the thesis.

**Effects of the Safe and Sound Protocol on Wellbeing and Auditory
Sensitivities among Adults with Auditory Hypersensitivities.**

A thesis
submitted in fulfilment
of the requirements for the degree
of
Master of Social Sciences [Psychology]
at
The University of Waikato

by
PRAVEEN KHATRI



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2025

Abstract

The Safe and Sound Protocol (SSP), an auditory intervention involving specifically filtered music, based on polyvagal theory, is marketed as a listening therapy that regulates the nervous system and is therefore recommended for a range of problems including trauma, anxiety and sensory sensitivities. There is limited research on the effectiveness of this intervention so far. Most studies have been focused on children and adults with autism and therefore, the effectiveness of SSP across different populations remains unclear. Using a single-subject, within-subject multiple baseline experimental design, this study evaluated the effectiveness of the SSP on well-being and auditory sensitivities among people with self-reported auditory hypersensitivities. Eight participants were randomly assigned to filtered (SSP) or non-filtered music conditions. Participants who received unfiltered music intervention were offered the filtered music intervention later. Three out of four chose to receive filtered music intervention. Psychological distress, positive and negative affect, psychological safety, and auditory sensitivity were measured before and after the intervention and were analysed using reliable change. The daily well-being ratings were taken throughout the study and were analysed using the percentage exceeding the median method. This study did not find any consistent evidence that the SSP reduces auditory hypersensitivity or improves well-being in these participants. Further research is necessary, employing both qualitative and RCT methodologies, to clarify the effects of SSP.

Acknowledgements

First and foremost, I would like to thank God for this life and the opportunity to pursue my studies and for guiding me throughout this journey.

Secondly, I want to express my deepest gratitude to my supervisor, Dr Carrie Barber for your unwavering support, guidance, and encouragement. Your invaluable feedback and mentorship have been instrumental in completing this thesis. Thank you for being my supervisor and being you!

I am also deeply thankful to the research participants who generously shared their time and experiences with me. Their willingness to participate and contribute to this research has been invaluable, and I am truly grateful for their trust and support in making this work possible.

A heartfelt thank you to my mother for being with me in some tough times in the last few years. You made me strong with your courage, choices and stories. Thank you for the nurturing food you cooked with so much love which gave me the strength to deal with the stress in this journey.

To my friend Sarah, I am immensely grateful to you for helping me get unstuck whenever I get tangled in this research. Thank you for your wisdom, willingness to help and being such a good friend. Also, a 'big thanks' to my classmates for being so awesome, supportive and genuine. Because of you guys, I felt less lonely in my academic journey.

I express my profound appreciation to my son's father and his parents for their love and care in looking after Omansh. Your care of Omansh allowed me to dedicate the necessary time and focus on my studies.

To my dear son, Omansh, thank you for allowing me to embrace my role as a student while also being your 'mummy.' Your understanding, patience, and support throughout my studies have meant the world to me. You are truly the best thing that ever happened to me, and I am endlessly grateful for the joy and love you bring into my life.

I want to acknowledge my sisters for their unconditional support and paving the way for me to pursue higher education. Both of you are very dear to me, and I appreciate your love, care, and unfiltered feedback.

I am sincerely thankful to my employer, the Department of Corrections, for granting me the scholarship to further my education. It is a huge blessing to be given an opportunity to study at my age without the worry of finances and work commitments. Thank you, Ara Poutama for changing my life!

Finally, I want to acknowledge my father who chose our education over cultural norms. He prioritised our education in times when girls in my family and village were considered a burden and were trained only for marriage. I am forever grateful to you and Mummy for your courage, vision and forward thinking. I dedicate all my success to you both. I know you would be bragging about our little achievements to your mates in heaven as you used to do here before!

Table of Contents

Abstract	2
Acknowledgements	3
Table of Contents	5
List of Tables	7
List of Figures	9
Chapter 1: Introduction	10
The Theoretical basis of the Safe and Sound Protocol – The Polyvagal theory	11
Auditory Hypersensitivity	14
Research on the effectiveness of the SSP	15
The Present Study	20
Hypothesis	21
Chapter 2: Method	22
Design	22
Participants	23
Data Analysis	32
Chapter 3: Results	34
Participant 1 “Isaac”	34
Participant 2 “Jenny”	36
Participant 3 “John”	37
Participant 4 “Sammy”	39
Participant 5 “Tim”	41

Participant 6 "Leena"	43
Participant 7 "Lily"	47
Overall effectiveness	53
Chapter 4: Discussion	55
Strengths	58
Future Direction	60
Conclusion	62
References	63
Appendix A	69
Appendix B	72
Appendix C	74
Appendix D	76
Appendix E	78
Appendix F	100
Appendix G	101

List of Tables

Table 1: Participant’s Demographics	24
Table 2: List of Measures Used Along With the Time of Use	25
Table 3: A List of Standard Deviation and Cronbach Alpha used to Calculate the Reliable change for DASS-21, PANAS, and NPSS.....	32
Table 4: Scores on Various Measures for Participant 1 Across Time Points.....	35
Table 5: Scores on Various Measures for Participant 2 Across Time Points.....	37
Table 6: Scores on Various Measures for Participant 3 Across Time Points.....	38
Table 7: Scores on Various Measures for Participant 4 Across Time Points.....	40
Table 8: Scores on Various Measures for Participant 5 Across Time Points.....	42
Table 9: Scores on Various Measures for Participant 6 Across Time Points for Unfiltered Music Conditions.....	44
Table 10: Scores on Various Measures for Participant 6 Across Time Points for Filtered Music Conditions.....	46
Table 11: Scores on Various Measures for Participant 7 Across Time Points for Unfiltered Music Conditions.....	48
Table 12: Scores on Various Measures for Participant 7 Across Time Points for Filtered Music Conditions.....	50
Table 13: Scores on Various Measures for Participant 8 Across Time Points in Unfiltered Music Conditions.....	51

Table 14: Scores on Various Measures for Participant 8 Across Time Points in Filtered Music Conditions.....	52
Table 15: Summarised Reliable Change Using Post-Pre-intervention Differences on Each Measure for All Participants.....	54

List of Figures

Figure 1: Daily Wellbeing Ratings for Participant 1 by Day.....	34
Figure 2: Daily Wellbeing Ratings for Participant 2 by Day.....	36
Figure 3: Daily Wellbeing Ratings for Participant 3 by Day.....	37
Figure 4: Daily Wellbeing Ratings for Participant 4 by Day.....	39
Figure 5: Daily Wellbeing Ratings for Participant 5 by Day for Unfiltered Music Listening Conditions.....	41
Figure 6: Daily Wellbeing Ratings for Participant 6 by Days for Unfiltered Music Listening Conditions.....	43
Figure 7: Daily Wellbeing Ratings for Participant 6 by Days for Filtered Music Listening Conditions.....	45
Figure 8: Daily Wellbeing Ratings for Participant 7 by Days for Unfiltered Music Listening Conditions.....	47
Figure 9: Daily Wellbeing Ratings for Participant 7 by Days for Filtered Music Listening Conditions.....	49

Chapter 1: Introduction

The Safe and Sound Protocol (SSP), an auditory intervention that claims to regulate the nervous system (The Safe & Sound Protocol, 2023), has gained popularity in recent years among practitioners dealing with autism, anxiety, depression, trauma, and other mental health concerns. The SSP is based on polyvagal theory and is thought to stimulate the vagus nerve acoustically and thereby retune the nervous system towards the cues of safety (Porges, 2022).

Originally called the Listening Project Protocol (LPP), the SSP was first trialled on children with autism in a study by Porges et al. (2013). Based on the polyvagal theory, this study was focused on identifying the connection between vagal regulation of the heart, as measured by Respiratory Sinus Arrhythmia (RSA, a measure of autonomic arousal) and auditory processing skills. Porges & colleagues (2013) described LPP as an intervention designed to engage the middle ear muscle for better auditory processing by optimising the frequencies related to human voice. This study reported positive effects on auditory processing and Respiratory Sinus Arrhythmia (RSA) in children diagnosed with autism. Later, using a randomised controlled trial, the positive results were replicated in another study (Porges et al., 2014). LPP was found to be effective in reducing auditory hypersensitivities and increasing sharing behaviour among children with autism (Porges et al., 2014). The promising results, along with a strong theoretical foundation in the polyvagal theory, facilitated SSP's popularity among mental health practitioners. Currently, SSP is recommended not only for auditory hypersensitivity in children and adults but also for supporting well-being in other ailments such as depression, anxiety, stress, sleep disturbances, trauma history, and neurodevelopmental disorders such as ASD, ADHD and learning difficulties (The Safe and Sound Protocol, 2023). However, there is a lack of empirical research to

evaluate the effectiveness of SSP in actually helping people reduce their auditory hypersensitivities and regulate their nervous system. This study aims to address this gap.

The Theoretical Basis of the Safe and Sound Protocol – The Polyvagal theory

The polyvagal theory (PVT), developed by Stephen Porges (1994), is based on the evolutionary development of the autonomic nervous system (ANS) in mammals that contributes to regulating defensive behaviours and social engagement in response to threats and safety. The polyvagal theory is named after the tenth pair of cranial nerves, the vagus nerves, which have several branches and are considered a family of nerves as they originate from several different areas of the brain stem (Porges, 1994). The vagus nerve has both sensory/afferent pathways (from peripheral organs to the CNS) and motor/efferent pathways (from the CNS to peripheral organs). Some of its motor neurons are myelinated, enhancing the speed and efficiency of information transmission (Tindal & Tadi, 2020).

The polyvagal theory (Porges, 1995) suggests that in mammals during evolutionary transitions, the efferent part of the vagus nerve developed two distinct branches, one originating from the dorsal area and the other appearing from the ventral region. The myelinated ventral vagus fibres not only regulate the heart and lungs but are also connected to the striated muscles of the face and head and are thought to contribute to social engagement and a calm state in the presence of safety cues (Porges, 2022). Porges (2009) coined the term 'neuroception' describing the continuous unconscious evaluation by the nervous system of environmental and bodily signals for risk and safety.

According to Porges (2023), the vagus nerve has an inhibitory effect on the heart (slowing the heart rate) in normal circumstances. During the low vagal tone, the heart beats faster. While responding to a threat, the ventral vagus complex is believed to withdraw to allow the sympathetic (flight/freeze) or the unmyelinated dorsal vagus complex (that leads to freeze response) to take over, depending on the type or perception of threat. These responses are hierarchically organised, meaning the higher neural circuits take precedence over the lower circuits. However, the older circuits are activated in succession when the newer circuit cannot ensure safety (Porges, 2023). In simple terms, the ventral vagus complex attempts to handle the situation calmly at first. When that fails, the sympathetic nervous system initiates fight or flight. Finally, when there seems to be no way out, the dorsal vagus complex takes over, leading to a freeze response. Therefore, the nervous system activates these responses hierarchically, starting with the most evolved system and progressing to more primitive responses when safety cannot be ensured (Porges 2023).

Porges (2022), proposes that the nervous system developed the downregulation of sympathetic activation (fight or flight) during evolution to support social engagement in mammals. When we feel safe, the ventral vagal complex slows the heart rate and adjusts the muscles that control the tone of voice and hearing to shift from a defensive to a receptive state. Alternatively, when we feel threatened, the defence response is activated, utilising sympathetic or parasympathetic dorsal vagal systems. Overall, the PVT highlights the importance of the perception of safety that supports the homeostatic function of health and restoration and enhances human social accessibility to others (Porges, 2022).

Middle ear bones get detached during embryonic development in mammals and form an ossicle chain (Porges, 2022). This chain that connects the eardrum to the inner ear

is regulated by small muscles via efferent vagal pathways. These muscles control the stiffness of the ossicle chain. When contracted, they filter out low-frequency sounds linked to predators by tightening the eardrum. Conversely, when the muscles relax, lower-frequency sounds pass through, allowing the detection of potential threats. This system is coordinated with the autonomic nervous system, where a calm state supports social engagement, and a defensive state shifts auditory focus to detecting threats (Porges, 2022; 2023).

Porges (2022) suggests a connection between auditory processing, behavioural regulation and autonomic state using the example of children with auditory processing difficulties who struggle to regulate their behaviour. He describes how auditory stimuli, such as soothing vocal tones, can regulate autonomic states, as seen in examples like a mother calming her infant using prosody in her voice or a pet responding to a human voice. He also notes that trauma survivors often show auditory hypersensitivity and poor autonomic regulation, reinforcing the idea that auditory processing is closely tied to the regulation of physiological and emotional states (Porges, 2022).

Porges used these examples as a rationale for developing an auditory intervention to regulate the nervous system, which led to the Safe and Sound Protocol. The SSP involves amplifying prosody in music by applying dynamic filters to remove low-frequency sounds and highlight high-frequency sounds to pre-recorded vocal music. This filtered music is thought to train the middle ear muscles that further help to focus on the frequency band of human speech (Porges, 2014, 2022). The low frequencies are algorithmically removed from this music and the frequency band associated with the human voice is modulated using computer processing (Porges, 2014). The SSP is a 5-hour auditory intervention marketed since 2017 by Unyte Integrated Listening

System as a vagus nerve stimulator (Porges 2022) and claimed to regulate the ANS and improve auditory processing (The Safe and Sound Protocol, 2023).

Auditory Hypersensitivity

Auditory Hypersensitivity (AH) is a common problem noticed in various disorders such as ASD, ADHD, traumatic brain injury, Tourette syndrome, migraines and other neurological conditions. It can sometimes also be linked to environmental factors and types of vocations (Czarnecka & Lachowska, 2020). AH is 'intolerance to some ordinary sounds that cause significant distress or impairment in day-to-day activities' (Tinda et al., 2018). The impact of AH is widespread, ranging from discomfort and physical pain to psychological, social and occupational problems such as irritability, mood decline and social aversion (Aazh et al., 2018; Czarnecka & Lachowska, 2022). Different terms have been used in the literature for AH such as hyperacusis and mesophonia, with some variation in definitions. AH and hyperacusis are used interchangeably with key symptoms including the sensation and perception of low to moderate-intensity sound as loud or very loud causing discomfort (Czarnecka & Lachowska, 2020). Misophonia is characterised by an unusually intense emotional and behavioural response to specific sounds or sound patterns that hold particular significance for the individual (Azah et al., 2018). Common sounds that cause negative reactions are chewing, breathing, clock ticking, pen clicking, dog barking, etc.

Two types of auditory hypersensitivities are noted in the literature based on the cause and mechanism underlying the development of AH (Czarnecka & Lachowska, 2020): peripheral auditory hypersensitivity (PAH) and central auditory hypersensitivity (CAH). PAH is related to the dysfunction of the peripheral part of the hearing organ for example damage to the facial nerve. The CAH could be due to the dysfunction of the central auditory pathway or could be a sign of limbic system abnormalities (Lucker &

Doman, 2015). There is a suggestion that the limbic system initiates a negative emotional response to sounds, which is then transmitted to the auditory cortex. Subsequently, the auditory cortex interprets this negative reaction, leading to the experience of hyperacusis (Aazh et al., 2018; Czarnecka & Lachowska, 2020). A different etiology has been suggested for AH in ASD (Matsuzaki et al., 2014; Lucker, 2013).

Research on the effectiveness of the SSP

To date, research on the impact of the SSP remains limited. Very few studies have been published on its outcomes and most of them predominantly focus on children with autism. Only one study exclusively examined the effects on adults (Kawai et al., 2023), while another included both children and adults (Heilman et al., 2023).

The first study was carried out by the developer of SSP, Dr Stephen Porges and other researchers. It was primarily focused on testing the hypothesis that the regulation of the heart by the vagus nerve (as measured by Respiratory Sinus Arrhythmia, RSA) and auditory processing are linked based on polyvagal theory (Porges et.al., 2013). They found that autistic children and youth had different autonomic profiles and poorer auditory processing than neurotypical children (Porges et., 2013). An auditory intervention called the Listening Project Protocol (LPP) was developed (now called the Safe and Sound Protocol) which was thought to improve auditory processing and increase vagal tone as measured by RSA. To test this, a second study was conducted using a subset of 33 participants from the ASD group. After establishing the baseline, these participants listened to the 5-hour filtered LPP music and were reassessed on auditory processing tasks and RSA following the listening intervention. This study reported improved auditory processing performance and increased RSA following the auditory intervention (SSP) among the ASD group. However, the lack of a control

group was a major limitation of this study. The observed effects could not be confidently attributed to the intervention and may have been influenced by other factors such as natural changes over time, participant expectations, or external variables (Porges et al., 2013).

Seeing the promising result of the auditory intervention used in the previous study and to overcome its limitations, another study was conducted by Porges and his colleagues (Porges et al., 2014) to evaluate the LPP's effectiveness in reducing auditory hypersensitivities and increasing social engagement in children diagnosed with autism. The Social Interaction Coding Scale (SICS) was used to measure participants' sharing behaviour using a play-based observation by a trained professional. Parents report data was also collected on a structured behaviour questionnaire developed by the researchers in their lab, focusing on 10 specific categories of their child's developmental and behavioural problems including hearing sensitivities.

This study involved two sequential randomised control trials. The first trial assessed if the intervention produced the effects on its own or was influenced by the research environment that included supportive play and social interactions. In this trial, 73 ASD-diagnosed children were randomly assigned to either the filtered music group (the LPP intervention) or the headphones-only group (with no music). Due to data loss, the comparison was limited to 36 participants from the filtered music group versus 28 participants from the headphones-only group. Significant enhancements were observed in hearing sensitivity, spontaneous speech, listening, and behaviour organisation within the filtered music group compared to the headphones-only group (Porges et al., 2014).

The second trial was conducted to see if the results were an effect of music or specific to the filtered music. To ensure an adequate sample size, twice as many participants were assigned to the filtered music group. No participants from the first trial were included in the second trial. In the second trial, due to attrition and data loss, the data of only 50 participants were compared to 32 children in the unfiltered music group. In both groups, participants passively listened to filtered or unfiltered music for approximately 45 minutes daily for 5 consecutive days using over-the-head headphones, under the supervision of a researcher and parents. In the second trial, significant improvements were observed only in auditory sensitivity and emotional control, indicating that the positive effects on auditory sensitivity, speech, and behaviour observed in the first trial for the filtered music group were likely due to music listening rather than the algorithmic music filtration (Porges et al., 2014).

Despite using a randomised controlled experimental design, the study reported several limitations that could impact the interpretation of its findings. Firstly, participants were concurrently receiving other treatments during the intervention and assessment period, making it challenging to isolate the specific effects of the intervention. Secondly, the participants were young and reported to be at the severe end of the Autism spectrum, therefore, the findings cannot be generalised to people who are older or have less severe ASD. Thirdly, unexpected improvements were observed in groups not receiving filtered music, possibly attributed to the intervention being conducted in a relaxed environment promoting social engagement and spontaneous play, along with a positive expectation bias and familiarity with the staff and context for the five sessions (Porges et al., 2014).

Five other studies have been published in the last two years evaluating the efficacy of SSP on sensory sensitivities and other measures with children and adults with ASD.

Out of these, two are case reports. In the first case report (Squillace, Lopez & Cohn 2022), the effects of SSP were studied in a 20-month-old child diagnosed with moderate ASD using a single-subject ABAB design (A was the intervention and B was the withdrawal phase with a 3-month gap between A1B1 and A2B2). The data were collected using parent reports. During the intervention phase, the parents administered the SSP for 10 consecutive days, for 30 minutes each day. This study reported improvements in language, facial expression, listening and processing, and emotional regulation (Squillace, Lopez & Cohn 2022). Again, the child received other therapeutic interventions simultaneously while being part of this study. Therefore, intervention effects cannot be isolated. Also, the data collection lacked a standardised tool and relied on subjective parent reports, limiting objectivity (Squillace, Lopez & Cohn 2022).

In another case report, the SSP was administered to a 10-year-old girl with Functional Neurological Disorder (FND) in nine sessions spread over six weeks, starting with 15-minute sessions and building up to 30 minutes (Rajabalee et al., 2022). The SSP was administered alongside other interventions as part of the Mind Body Rehabilitation Programme (MBRP). This program included physical therapy, psychological therapy, pharmacology, family work and hospital school to maintain normal daily functions. The SSP was administered following other interventions and significant improvements were noted in her communication, engagement in additional therapies, and physical movements. The child's Depression, Anxiety, and Stress (DASS) scores returned to normal one month after completing the protocol (Rajabalee et al., 2022). Similar to the previous case report, utilising other therapies alongside the SSP is one of the key limitations as it is hard to distinguish the cause of positive results noted in the study.

A prospective single-arm study was conducted by Heilman et al. (2023) to assess the effectiveness of the SSP on sensory sensitivities, digestive problems and selective

eating (as measured by the Brain-Body Center Sensory Scales - BBCSS) in a sample of 37 participants with ASD ranging in age from 7 to 49 years. The SSP was delivered in person at a clinic or school or remotely for home-based participants for one hour per day for five consecutive days. The data were collected at baseline, one week, and four weeks follow-up post-intervention. A significant decline was noticed in auditory hypersensitivity, auditory hyposensitivity to voices, visual sensitivity, and non-social tactile hypersensitivity at one week and four weeks follow-up compared with baseline. Furthermore, delayed effects were observed at the four weeks follow-up including a decrease in selective eating and tactile hypersensitivities. However, no effects of SSP were noted on social touch aversion. The lack of a control group is a key limitation of this study (Heilman et al., 2023).

So far only one study has focused entirely on an adult ASD sample (Kawai et al., 2023) involving 6 participants in the age range of 21 – 44 years. The SSP was administered for an hour each day for five consecutive days where the intervention was carried out in the outpatient clinic for the first and the last day and in-between days the intervention was done at home. The data were collected before and after one hour of the intervention and after one month of follow-up on social responsiveness, depression, anxiety, quality of life and sensory sensitivities. In this study, the SSP intervention only showed improvements on the Social Awareness subscale of the social responsiveness scale (SRS-2) reported by family members (Kawai et al., 2023). The SRS-2 self-report and the other subscale of SRS-2 family report did not show any significant changes (Kawai et al., 2013). However, two participants subjectively reported improvements in sleep, awareness and self-regulation of hypersensitivity respectively during follow-up. This study had three main limitations: a small sample size (only 6 participants), lack of a control group, and the reliability of the family reports (Kawai et al., 2023).

The Present Study

So far only a few studies have been published to evaluate SSP's effectiveness. Most of these studies are focused on children or adults with ASD (Porges et al., 2013; Porges et al., 2014; Heilman et al., 2023; Kawai et al., 2023) and included participants simultaneously receiving other therapies (Porges et al., 2013, Porges et al., 2014; Rajabalee et al., 2022). Some of these studies lacked a control group (Porges et al., 2013, Heilman et al., 2023; Kawai et al., 2023). It is important to have a control group to see if the noted effects are due to filtration in the music or simply an effect of music and/or a placebo effect. The most well-supported effects (in the one study that did use a non-filtered music control group) have been on auditory hypersensitivities (Porges et al., 2013; Porges et al., 2014). The providers of SSP and SSP-trained clinicians are recommending the use of SSP to people across the lifespan for several problems such as sleep issues, depression, anxiety, trauma healing, and sensory sensitivities to people with or without ASD (The Safe and Sound protocol, 2023). There is a need for independent research to evaluate the effectiveness of the SSP among adults who are not receiving new interventions or therapies simultaneously while receiving SSP intervention. The present study aims to assess the effectiveness of the SSP on the well-being and sensory sensitivities of people who self-reported having auditory hypersensitivities. This study used a within-subject multiple baseline experimental design. The participants were randomly assigned to experimental (filtered music) and control (unfiltered music) groups and were assessed at enrolment, pre-intervention, post-intervention, and 2-week follow-up.

Hypothesis

The participants who receive the filtered SSP music will show more improvement in well-being as measured by Daily Wellbeing Ratings (DWR), a sense of safety as measured by NPSS, and a reduction in distress as measured by DASS-21 and PANAS when compared to the unfiltered music intervention. The filtered SSP music intervention is expected to show a reduction in sensory hypersensitivities as measured by BBCSS when compared to the unfiltered music intervention.

Chapter 2: Method

Design

The study used a within-subject, multiple baseline experimental design. A baseline was established for each participant separately, followed by filtered or unfiltered music intervention, followed by another baseline before collecting follow up data. Participants who received the unfiltered music intervention were offered to receive filtered music condition. The study design was ABAF, ACAF and ACAFABAF, where A is the baseline, B is filtered music intervention, F is the follow-up, and C is unfiltered music intervention. Outcomes were measured using a brief daily wellbeing rating as well as assessments of sensory sensitivities, sense of safety, positive and negative affect, and emotional distress. The participants were randomly assigned to a five-hour music intervention with either filtered music or unfiltered music by flipping a coin for the first five participants to decide the allocation; the later participants were given the opposite allocation of the top five, to minimise the likelihood of uneven group sizes. The participants were not aware of their allocation to the control or the experimental group until the follow-up. After the control participants completed their follow-up phase, they were told they had received unfiltered music intervention, and they were given the option of repeating the whole intervention process with the filtered music, including the baseline and follow-up periods. Three out of four participants took up the offer of filtered music intervention.

The study was reviewed and overseen by the University of Waikato Human Research Ethics Committee HREC(Health)2023#8.

Participants

Participants were recruited (refer to appendix A for the recruitment poster) in Hamilton through advertising on the University of Waikato campus, social media pages of organisations such as Voices from the Spectrum, Autism New Zealand, a local audiologist, and local health centres. Recruitment took place between 17 May 2023 and 1 Feb 2024. Inclusion criteria consisted of adults aged 18 years or above with self-identified auditory hypersensitivities and no prior exposure to the Safe and Sound Protocol (SSP). Exclusion criteria consisted of seizure episodes in the last 5 years, traumatic brain Injury (TBI) in the last year, and starting new medication or therapy services in the month before the study or scheduled to start during participation in the study.

A total of 14 people showed interest in participating in this study; however, only 9 could start the study. For people who could not start, two didn't meet the inclusion criteria (one had only tinnitus and no auditory hypersensitivity; another did not report having auditory hypersensitivity but only startle responses to sudden loud sound), one had a medical condition requiring ongoing medical interventions, another one was planning to start psychotherapy during the proposed intervention period and lastly, one participant couldn't commit to participating due to other lifestyle demands. Of the nine who started the study, one person withdrew before starting the intervention due to a change in personal circumstances.

Table 1 shows the demographics of the eight participants who completed the intervention. The participants didn't receive any incentive for participating; however, they received the intervention free of cost.

Table 1*Participants' Demographics.*

Characteristics	Overall Sample	Filtered Music	Unfiltered Music
Age mean	34.125	35.25	33
Age range	21-42	21-41	22-42
Gender			
Male	3	2	1
Female	5	2	3*
Ethnicity			
Pakeha/European	4	1	3
Asian	1	0	1
Other	3	3	0
Highest Qualifications			
High school	3	1	2
Bachelor's degree	1	0	1
Post Graduate	4	3	1

Note. This is the initial grouping. *Three females from the unfiltered music intervention conditions later received filtered music conditions.

Measures

Four measures of subjective psychological states were used to assess the effects of SSP; these were administered at enrolment, just before the first listening session, just after the last listening session, and 2 weeks after the last listening session. Table 2 shows the timing of all measures in the study.

Table 2

List of Measures Used Along with the Time of Use.

Measures	Enrolment	Start of intervention	During (Daily)	End of intervention	Follow up
DASS-21	x	x		x	X
PANAS-SF	x	x		x	X
NPSS	x	x		x	X
BBCSS	x	x		x	X
DWR	x	x	X	x	X

Note. DWR- Daily Wellbeing Ratings; DASS21 = Depression Anxiety and Stress Scale 21 items; PANAS-SF = Positive and Negative Affect Schedule -Short Form, NPSS = Neuroception of Psychological Safety Scale; BBCSS = Brain-Body Center Sensory Scale;

Depression Anxiety and Stress Scale Short Form (DASS-21).

The DASS-21 is a 21-item self-report questionnaire that measures the core symptoms of depression, anxiety, and stress over the past seven days (Lovibond & Lovibond, 1995). Items are rated on a four-point Likert-type scale ranging from 0 (*did not apply to me at all*) to 3 (*applied to me very much, most of the time*). The DASS-21 produces three subscales: Depression (DASS-D), Anxiety (DASS-A) and Stress (DASS-S) by adding the scores for each of the relevant items. The scores range from 0-21 within each subscale, with higher scores indicating higher symptomatology. DASS-21 is a popular measure used in clinical as well as non-clinical samples to measure negative emotional states (Medvedev, 2023). All three subscales have shown high internal

consistency ranging from 0.82 - 0.91 (Antony et al., 1998; Lovibond & Lovibond, 1995; Henry & Crawford, 2005).

Positive and Negative Affect Schedule - Short Form (PANAS - SF)

The Positive and Negative Affect Schedule (PANAS-SF) is a 20-item self-report questionnaire designed to measure positive affect (PA) and negative affect (NA). Developed by Watson, Clark, and Tellegen (1988), it consists of two separate subscales, one for positive affect and another for negative affect, with each subscale containing a list of adjectives that describe various emotional states. The positive affect subscale includes emotions like joy and enthusiasm, while the negative affect subscale gauges feelings such as fear and anger. Respondents rate the extent to which they have experienced each emotion over the last week.

The PANAS has demonstrated strong internal consistency for both the positive (Cronbach's alpha ranging from 0.85 to 0.95) and negative affect (0.84 to 0.87) subscales (Crawford & Henry, 2004; Heubeck & Wilkinson, 2019). It has been extensively validated, showing good psychometric properties (Merz et al., 2013; Roemer & Medvedev, 2023; Watson & Clark, 1994). It is sensitive to changes in affective states, making it a valuable tool for researchers and clinicians studying interventions or treatments that aim to influence emotional experiences (Crawford & Henry, 2004; Serafini, et al., 2016).

Neuroception of Psychological Safety (NPSS)

The Neuroception of Psychological Safety Scale (NPSS) is a new instrument designed to measure the perception of psychological safety within an interpersonal context (Morton et al., 2022). It is a self-report measure with 29 items scored on a five-point Likert-type scale (1= strongly disagree to 5= strongly agree). It asks the user to rate

each statement that describes their feelings over the past week (for example, *there was someone who made me feel safe, I felt understood*, etc.). Informed by the polyvagal theory, NPSS has three subscales to measure the perception of safety: social engagement, compassion, and bodily sensations. Higher scores in these areas indicate a greater sense of psychological safety. The total score was calculated by the mean of the items (Morton et al., 2021). The mean of NPSS's three subscales was used to evaluate change after the intervention. The NPSS was found to have a consistent factor structure and internal consistency (Mortan et al., 2022, 0.95).

The SSP is thought to calm the nervous system, resulting in an enhanced sense of safety and social engagement (Porges, 2023). Hence it would be useful to measure the outcome of perception of one's psychological safety.

Brain Body Center Sensory Scale (BBCSS)

The 50-item adult self-report form of the BBCSS was used in this study. The BBCSS assesses sensory hypersensitivities in four domains; auditory, visual, tactile, digestive problems and selective eating (Kolacz et al., 2018). Items are rated on a four-point Likert scale ranging from 4 (almost always) to 1 (almost never). There is also an option of "not applicable/not sure" for each item. The BBCSS produces four subscale scores by adding the scores for each of the relevant items, with higher scores indicating higher sensitivity. Only the Auditory subscale data are analysed in this study.

The BBCSS is a fairly new instrument. Its psychometric properties were evaluated by Kolacz et al. (2018) using a caregiver report form to identify sensory sensitivities in 333 individuals (children and adults) with Fragile X Syndrome, of which 41% also had Autism Spectrum disorder. The psychometric properties of the self-report form are yet to be explored.

Internal consistency estimates showed uni-dimensionality for each subscale using the caregiver report form (Kolacz et al., 2018). Test-retest reliability (two months apart) ranged from 0.71 to 0.83 (Kolacz et al., 2018).

The BBCSS self-report adult form was administered to measure auditory sensitivity at the time of enrolment, pre-intervention, post-intervention, and follow-up using an online Qualtrics survey.

Daily Well-being Ratings (DWR)

An adapted version of the Well-being Scale (a repeated measure used by Feinstein et al., 2018) was utilised to measure the perceived well-being of the study participants daily. It consisted of nine items measuring various constructs related to general wellness: sleep, relaxation, muscle tension, anxiety, mood, contentedness, freshness, energy, and overall well-being on a 10-point Likert Scale (1-10; very poorly/none/not at all to very well/most/extremely).

The participants were sent a daily reminder (at a set time chosen by the participant) with the link attached to complete the daily well-being questionnaire. These daily reminders were sent via text message throughout the study for each participant separately and took a minute to answer.

Procedure

The researcher (Praveen Khatri) and the research supervisor (Dr. Carrie Barber) completed the foundational SSP training & certification provided by the Unyte ILS to safely deliver the SSP. The training was on-demand, online, self-paced, 6.5 hours long. It covered the foundations of SSP (the polyvagal theory), the clinical aspects of delivering SSP (psychoeducation, co-regulation, titration, clinical application), and how to include SSP in practice.

All the interested participants were screened for their suitability over the phone and were sent an information sheet detailing the requirements and time commitment needed for the study. A meeting was organised with interested participants (individually) to explain the requirements and the procedure and the consent was signed. After getting written consent, participants were asked to fill out the enrolment questionnaire that included demographic information such as age, gender, ethnicity, educational qualification, any medication they might be taking, as well as four pre-treatment measures (Table 2). A unique ID (first letters of their first and last name with the last 3 digits of their phone number) was allocated to each participant to facilitate data management. Following this, the participants were assigned to either a control (unfiltered music) or an experimental (filtered music) condition using the process described above.

After the enrolment session, the baseline phase started. In the baseline phase, participants were asked to fill out the 9-item Daily Well-being Ratings (DWR) at the same time each day at a time chosen by the participant. They were sent the link to complete the scale at those times. To enter into the intervention phase, participants needed a 'stable' baseline. The criterion for the stable baseline was defined as "at least seven days' data with a variation of three points or less and no clear trend" on the 'general well-being' item of the DWR.

Once the baseline was established, participants were invited to start their intervention phase. The intervention phase consisted of listening to 5 hours of either filtered (Safe and Sound Protocol) or unfiltered music (depending on being in the control or experimental conditions) provided by the Unyte ILS, Australia (The Safe & Sound Protocol, 2023). The music was the same in both conditions (sounded similar) and accessed in the same way, the only difference was the filtration which is not detectable

to the listener. The participants were asked to choose from classical (non-vocal) or vocal popular music. The first, last, and follow-up sessions were in person in the university research lab for six out of eight participants, and other listening sessions were completed independently, typically in the participant's home using the Unyte ILS app. One participant relocated to a different city following enrolment so couldn't come to the research lab and therefore, received instruction over video call and completed all sessions remotely. Another participant could also not attend the last and the follow-up session in person and hence, completed the listening and questionnaire remotely.

In the first listening session, participants were asked to complete the pre-intervention questionnaire, administered online using the Qualtrics platform (Table 2). After filling out the questionnaire, they were given instructions for listening to the music that included using extramural headphones without a noise cancelling feature, keeping the same volume throughout listening, and taking pauses if required. They were instructed to listen to this music in a quiet and peaceful environment and can combine the listening with relaxing activities only such as colouring & knitting. They were encouraged to remain awake while listening. If fallen asleep then they were asked to repeat that listening session. The intervention was provided through Unyte ILS app which was downloaded on their phones. All the procedures and instructions were kept the same for the experimental and the control conditions.

The first 10-15 minutes of the music was administered in the research room with the researcher present to monitor the reaction to the music and make adjustments if required (taking pauses, gentle stretches, breathing). All participants tolerated the first 10 minutes of the music well. The participants were asked to listen to at least 5 minutes to a maximum of an hour of music each day in a relaxing environment in their own space (home, office, etc.) until they completed all five hours. They were suggested to

contact the researcher if they faced any issues or unpleasant reactions due to listening. Two out of eight participants reported mild headaches or irritability while listening to music at home which improved within 2-5 days. They were asked to take breaks, relax, and listen when ready. If the reaction persisted, they were asked to stop listening for the day. The SSP training suggested “less is more” for filtered music as some individuals had difficulty tolerating an hour of filtered music. The average (median) time taken by participants to listen to 5 hours of music was 14 days and ranged from 7 days to 36 days. The Unyte ILS app was able to show how much listening is completed by each participant and when.

The last 15-20 minutes of listening (of the fifth hour) were completed in the research lab, followed by filling out the post-intervention questionnaire. The daily well-being ratings continued throughout the study until the follow-up session for each participant. Two weeks after their last listening session, the participants were invited to the research lab for the follow-up session, where they filled out the follow-up questionnaire. Two participants couldn't come to the research lab for their follow-up sessions, so they completed the follow-up survey remotely.

After completing the follow-up survey, each participant was informed of the type of music they had been exposed to (filtered or unfiltered). Participants who had initially received unfiltered music were offered the opportunity to engage in experimental conditions with filtered music. Three out of four participants opted to receive filtered music upon completion of their control conditions. To ensure the baseline was reestablished, a minimum interval of one week was provided before the filtered music intervention began.

Data Analysis

Each participant was given a pseudonym to maintain anonymity and ease of presenting the data. The percentage exceeding the median (PEM) method was used to analyse the daily well-being data. In PEM, a percentage below 70 is considered low or poor effect, 70% - 80% is considered moderate effect and 80% and above is considered high effect (Ma, 2006, as cited in Şen & Sen, 2019).

To analyse DASS-21, PANAS and NPSS data, the reliable change was calculated with the Jacobson & Truax (1991) method using the Standard Deviation (SD) and internal consistency (Cronbach's alfa- α) from the normative sample as depicted in Table 3 (Lovibond & Lovibond, 1995; Crawford & Henry, 2004; Morton et al., 2022). The difference between post-intervention and pre-intervention scores was calculated. The difference greater than the reliable change was considered significant and used to draw overall inferences.

Table 3

A list of Standard Deviation and Cronbach Alpha was Used to Calculate the Reliable Change for DASS-21, PANAS, and NPSS.

		Standard Deviation (SD)	Cronbach's alpha (α)	Reliable Change (RC) Criteria RC= $1.96\sqrt{2(s_M)^2}$
DASS- 21^a	Depression	3.87	.88	3.72
	Anxiety	2.95	.82	3.47
	Stress	4.20	.90	3.68
	Total	9.66	.93	7.08

PANAS^b	Positive Affect	7.7	.89	7.08
	Negative Affect	5.9	.85	6.33
NPSS^c		14.85	.95	9.20

Note. DASS-21 = Depression, Anxiety and Stress Scale; PANAS = Positive and Negative Affect Scale; NPSS = Neuroception of Psychological Safety; ^a = Henry & Crawford, 2005; ^b = Crawford & Henry, 2004; ^c = Morton et al., 2022, S_M = Standard error of measurement (i.e. $SD\sqrt{1 - \alpha}$) (Blampied, 2022).

The reliable change could not be calculated for BBCSS due to mean and standard deviation information missing for the normative sample and also because their sample was a caregiver report and not a self-report (Kolacz et al., 2018). Therefore, only the differences are shown for the BBCSS auditory subscale.

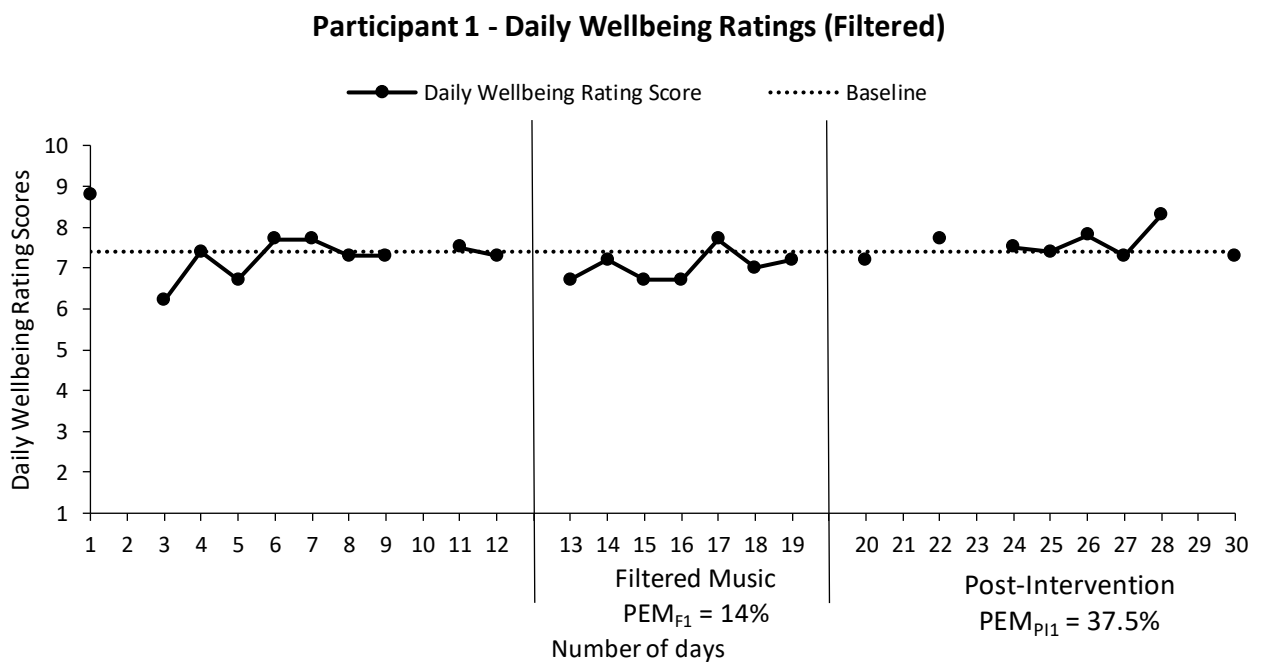
Chapter 3: Results

Participant 1 “Isaac”

Issac received filtered music intervention and took seven days to complete the five hours of filtered music. His DWR scores (Figure 1) showed no consistent pattern of change in the daily well-being scores comparing baseline to intervention and post-intervention periods.

Figure 1

Daily Wellbeing Ratings for Participant 1 by Day.



Note. PEM_{F1} = Percentage exceeding the median for filtered music intervention for Participant 1; PEM_{P11} = Percentage exceeding the median for post-intervention for Participant 1; the Daily Wellbeing Scores are the mean of all items.

Issac's total scores on the DASS-21 decreased when his pre-intervention scores were compared to his follow-up scores (Table 4). However, the difference in his pre and post-intervention scores did not reach the criteria for reliable change. His scores on

the PANAS Positive Affect (PA) increased from pre-intervention to post-intervention (Table 4). However, his scores on the PANAS Negative Affect (NA) did not show a significant difference.

Issac's scores on the BBCSS Auditory subscale (to measure auditory hypersensitivities) showed an increase from pre-intervention to the post-intervention phase and returned to almost the same scores as the enrolment when measured at follow-up (Table 4). Issac's scores on NPSS increased from pre-intervention to post-intervention, however, remained unchanged when enrolment and post-intervention scores were compared indicating no change in his perception of his psychological safety.

Table 4

Scores on Various Measures for Participant 1 Across Time Points.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS Total
Enrolment	5	15	19	39	49	17	36	48.3
Pre- Intervention	0	9	14	23	38	19	35	42.0
Post Intervention	0	8	12	20	45	20	47	48.3
Follow up	2	3	7	12	44	20	37	47

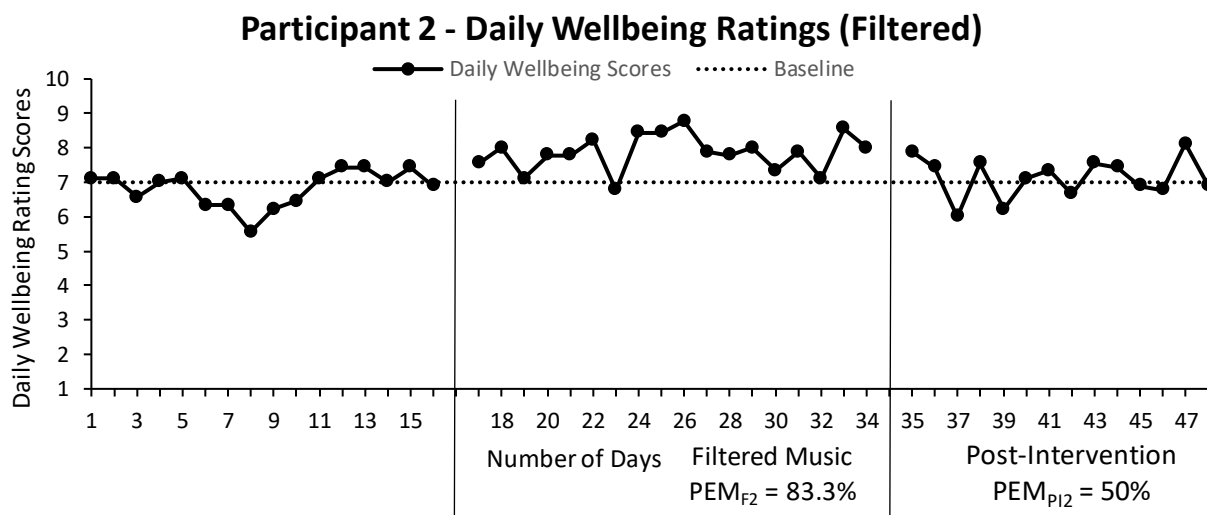
Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain-Body Center Sensory Scales (only Auditory subscales scores are shown); DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Participant 2 “Jenny”

Jenny received filtered music intervention and took 17 days to complete listening to the five hours of filtered music. Her DWR scores (Figure 2) showed a moderate increase during the filtered music intervention phase. However, her DWR scores almost returned to her baseline level at the time of follow-up after completing the filtered music intervention. ($PEM_{F2} = 83.3\%$; $PEM_{P12} = 50\%$).

Figure 2

Daily Wellbeing Ratings for Participant 2 by Day.



Note. PEM_{F2} = Percentage exceeding the median for filtered music intervention for Participant 2; PEM_{P12} = Percentage exceeding the median for post-intervention for Participant 2.

Jenny’s total scores on the DASS -21 scale did not change significantly from pre-intervention to post-intervention or follow-up. Her PA and NA scores increased slightly from pre-intervention to post-intervention however, the difference wasn’t significant (Table 5). Jenny’s scores on the BBCSS auditory subscale fluctuated as her scores initially decreased from pre-intervention to post-intervention and then increased

slightly from post-intervention to follow-up. Her scores on NPSS increased from pre-intervention to post-intervention however, reducing slightly at the time of follow-up.

Table 5

Scores on Various Measures for Participant 2 Across Time Points.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS
Enrolment	2	1	8	11	24	22	30	38.3
Pre- Intervention	1	3	5	9	31	13	25	36.7
Post Intervention	1	2	7	10	33	15	20	43.7
Follow up	2	2	7	11	37	17	27	42

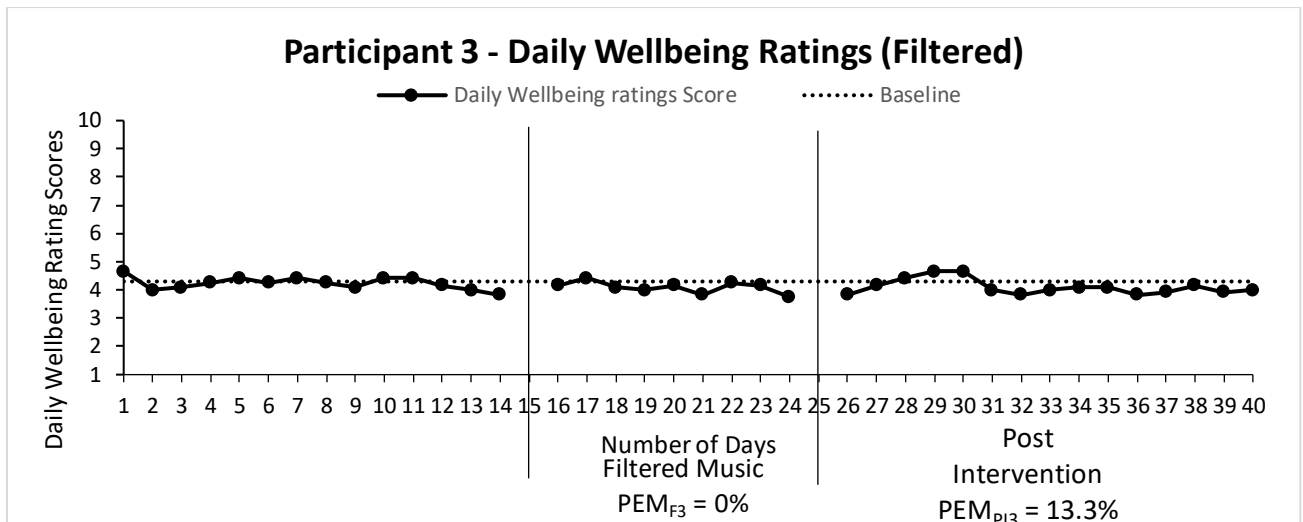
Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Participant 3 “John”

John received filtered music intervention and took nine days to complete the five hours of music. His DWR scores (Figure 3) did not change much during intervention and post-intervention. ($PEM_{F3} = 0\%$; $PEM_{P13} = 13.3\%$).

Figure 3

Daily Wellbeing Ratings for Participant 3 by Day.



Note. PEM_{F3} = Percentage exceeding the median for filtered music intervention for Participant 3; PEM_{P13} = Percentage exceeding the median for post-intervention for Participant 3.

John's total scores on the DASS -21 scale decreased from pre-intervention to post-intervention however, at the time of follow-up, his scores returned to an almost similar level to pre-intervention (Table 6). His PA and NA scores increased from pre-intervention to post-intervention. However, his PA scores returned to pre-intervention levels at the time of follow-up but remained increased for NA. John's scores on the BBCSS Auditory subscale reduced from pre-intervention to post-intervention however, returned to a similar level as pre-intervention when measured at follow-up. His NPSS scores fluctuated minutely at all data points and didn't show any significant difference (Table 6).

Table 6

Scores on Various Measures for Participant 3 Across Time Points.

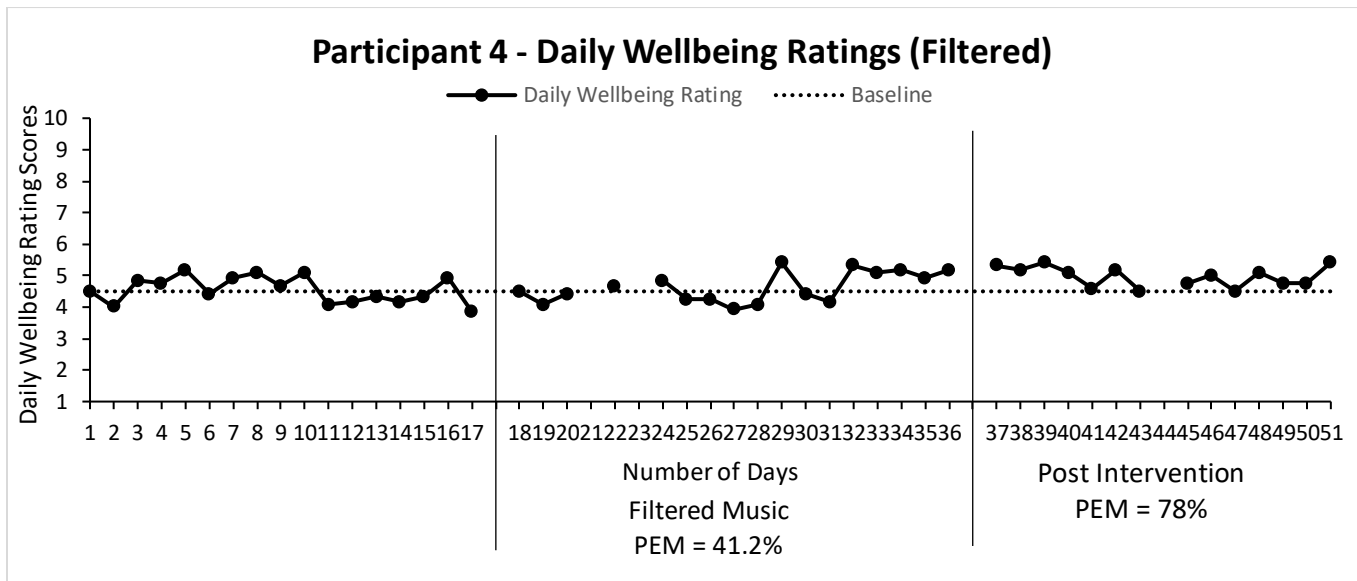
Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS
Enrolment	8	8	7	23	25	17	34	27.7
Pre- Intervention	16	8	10	34	15	30	36	27.7
Post Intervention	13	7	8	28	21	42	32	25.3
Follow up	12	11	13	36	15	39	37	28.7

Participant 4 “Sammy”

Sammy received filtered music intervention and took 19 days to complete listening to the five hours of filtered music. Her DWR scores (Figure 4) increased after the completion of the filtered music listening phase ($PEM_{F4} = 41.2\%$; $PEM_{P14} = 78\%$).

Figure 4

Daily Wellbeing Ratings for Participant 4 by Day.



Note. PEM_{F4} = Percentage exceeding the median for filtered music intervention for participant 4; PEM_{PI4} = Percentage exceeding the median for post-intervention for participant 4. The DWR data is missing for days 21, 23 and 44.

Sammy's follow-up data is missing. Her total scores on the DASS scale decreased from pre-intervention to post-intervention, however, increased from the enrolment phase. Her PA scores remained the same following filtered music intervention. Her NA scores increased from pre-intervention to post-intervention as shown in Table 7. Sammy's scores on the BBCSS scale showed an increase in auditory hypersensitivity subscale from pre-intervention to post-intervention. Her NPSS scores remained unchanged from pre-intervention to post-intervention (Table 7).

Table 7

Scores on Various Measures for Participant 4 Across Time Points.

Time Points	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS
Enrolment	3	5	8	16	30	28	30	33.7

Pre- Intervention	7	7	13	27	30	29	33	31.7
Post Intervention	6	4	14	24	30	36	38	31.7
Follow up	Missing data	Missing data	Missing data	Missing data	Missing data	Missing data	Missing data	Missing data

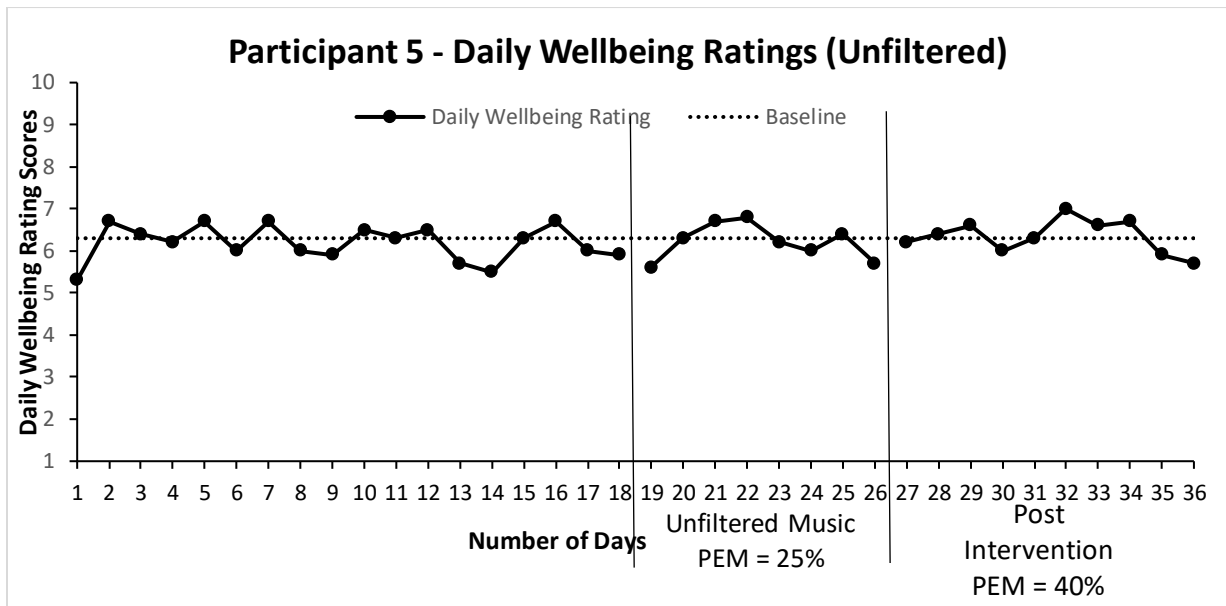
Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Participant 5 “Tim”

Tim received unfiltered music intervention and took eight days to complete five hours of listening to unfiltered music. His DWR scores (figure 5) showed no consistent pattern of change in the daily well-being scores comparing baseline to intervention and post-intervention periods. ($PEM_{NF5} = 25\%$; $PEM_{PI5} = 40\%$).

Figure 5

Daily Wellbeing Ratings for Participant 5 by Day for Unfiltered Music Listening Conditions.



Note. PEM_{NF5} = Percentage exceeding the median for Unfiltered music intervention for participant 5; PEM_{PI3} = Percentage exceeding the median for post-intervention for participant 5.

Tim's total scores on the DASS-21 remained the same from pre-intervention to post-intervention (Table 8). There was not much difference between Tim's scores on the PANAS positive subscale from pre-intervention to post-intervention and follow-up. However, his PANAS Negative subscale scores decreased from pre-intervention to post-intervention and then returned to almost the same scores as enrolment. There was a slight increase in Tim's scores for NPSS from pre-intervention to post-intervention and then returning to almost the same level at follow-up as the pre-intervention scores. His scores on the auditory subscale of BBCSS increased slightly from pre-intervention to post-intervention and follow-up (Table 8).

Table 8

Scores on various measures for Participant 5 Across Time Points.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS
Enrolment	5	2	10	17	28	21	35	34.0
Pre- Intervention	1	3	5	9	31	22	29	37.7
Post Intervention	2	2	5	9	30	14	31	39.0
Follow up	2	2	6	10	31	20	32	37.0

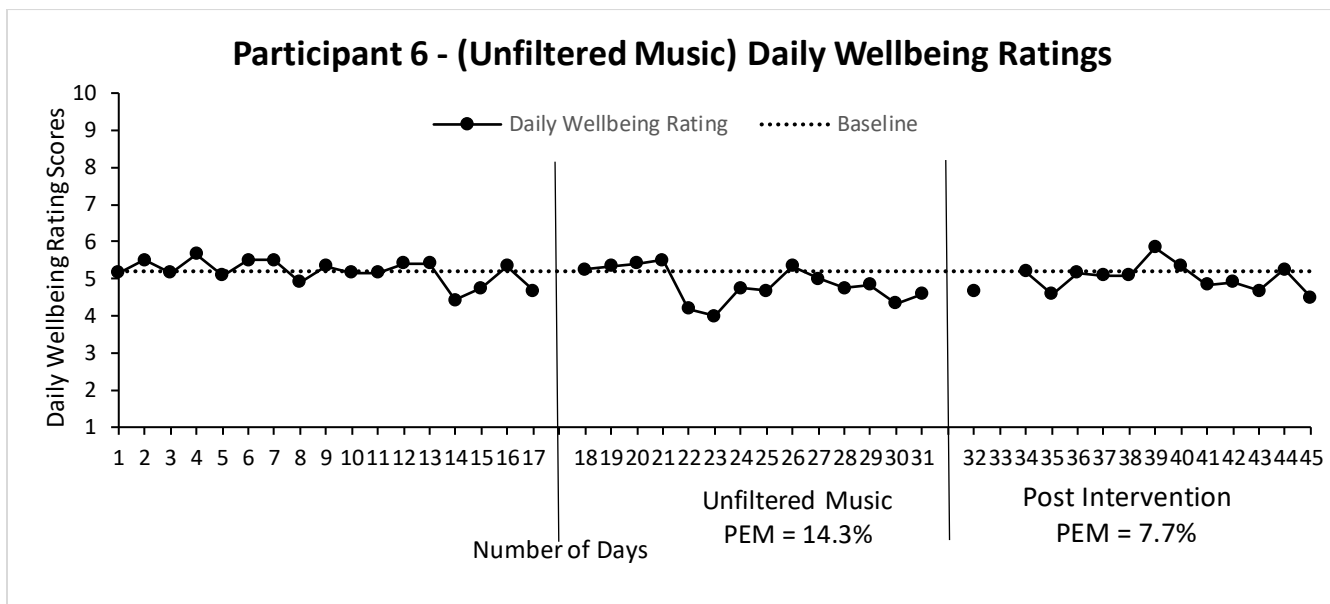
Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Participant 6 “Leena”

Leena initially received unfiltered music and took 14 days to complete five hours of unfiltered music intervention. Her DWR scores (Figure 6) showed no major difference in her daily well-being scores as a result of listening to unfiltered music. ($PEM_{NF6} = 14.3\%$; $PEM_{PINF6} = 7.7\%$).

Figure 6

Daily Wellbeing Ratings for Participant 6 by Days for Unfiltered Music Listening Conditions.



Note. PEM_{NF6} = Percentage exceeding the median for Unfiltered music intervention for Participant 6; PEM_{PINF6} = Percentage exceeding the median for post-intervention for Participant 6.

Table 9

Scores on Various Measures for Participant 6 Across Time Points for Unfiltered Music Listening Conditions.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS
Enrolment	8	7	12	27	29	26	39	26.7
Pre-Intervention	10	9	8	27	24	22	36	30.0
Post Intervention	7	10	10	27	33	27	39	31.3
Follow up	11	8	11	30	25	26	36	27.7

Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Leena's total scores on the DASS-21 (Table 9) remained the same from pre-intervention to post-intervention. Her PA and NA scores increased from pre-intervention to post-intervention and then returned to similar levels at follow-up as pre-intervention for PA. Her scores on the BBCSS auditory hypersensitivity subscale showed a slight increase from pre- to post-intervention however, no change when her enrolment and post-intervention data were compared. Similarly, no substantial change was noticed when her NPSS data was compared from enrolment to follow-up.

After completing her follow-up for the unfiltered conditions, Leena participated in the filtered music condition. Therefore, she was aware of receiving the filtered music intervention.

Leena's DWR scores (Figure 7) showed no consistent pattern of change in the daily well-being scores comparing baseline to intervention and post-intervention periods in filtered music conditions. ($PEM_{F6} = 3\%$; $PEM_{PIF6} = 6.25\%$).

Figure 7

Daily Wellbeing Ratings for Participant 6 by Days for Filtered Music Listening Conditions.

Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Leena's DASS total scores showed no substantial change from pre- to post-intervention conditions. Leena's PANAS positive scores increased and her negative subscales scores decreased from pre- to post-intervention (Table 10).

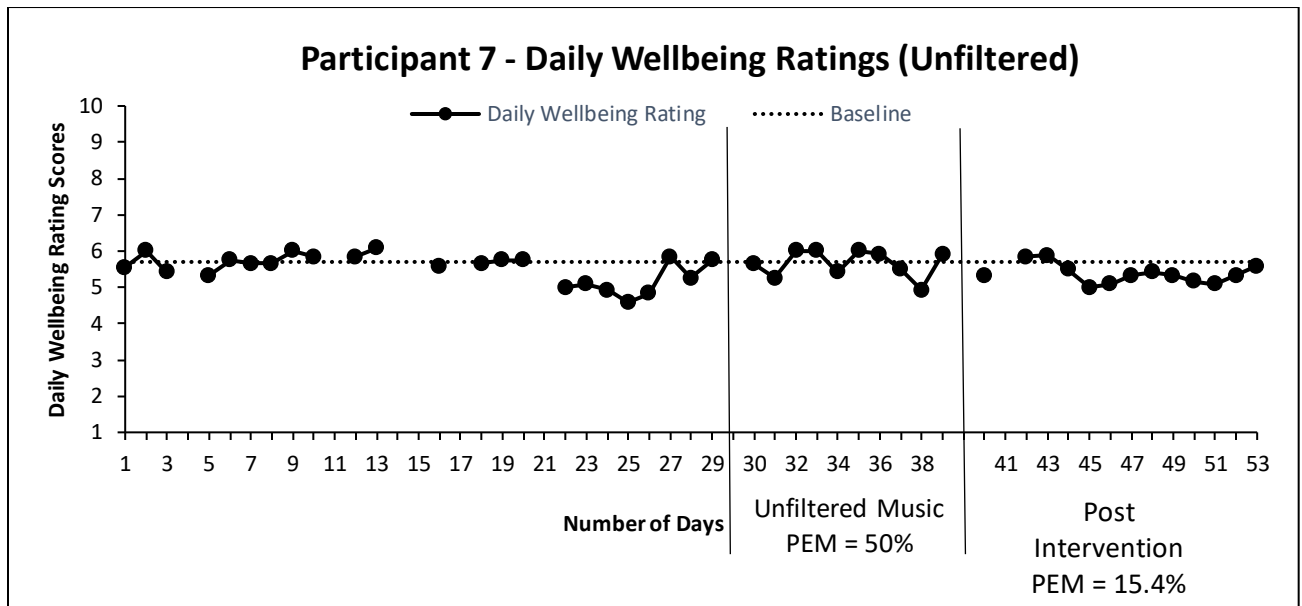
There wasn't much difference in her auditory hypersensitivity subscale scores. Lastly, there was a slight increase in her NPSS scores (Table 10).

Participant 7 "Lily"

Lily initially received unfiltered music conditions and took nine days to complete the five hours of unfiltered music. Her DWR scores (Figure 8) showed no consistent pattern of change in the daily well-being scores comparing baseline to intervention and post-intervention periods as a result of listening to unfiltered music. ($PEM_{NF7} = 50\%$; $PEM_{PINF7} = 15.4\%$).

Figure 8

Daily Wellbeing Ratings for Participant 7 by Days for Unfiltered Music Listening Conditions.



Note. PEM_{NF7} = Percentage exceeding the median for Unfiltered music intervention for Participant 7; PEM_{PINF7} = Percentage exceeding the median for post-intervention for Participant 7. The data is missing for day 4, 11, 14, 15, 21.

Table 11

Scores on various measures for Participant 7 across time points in unfiltered music conditions.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS Total
Enrolment	7	4	11	22	37	28	45	45
Pre- Intervention	8	2	15	25	35	35	38	38.7
Post Intervention	8	1	10	19	34	19	43	41.3
Follow up	8	2	9	19	30	16	37	39.7

Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

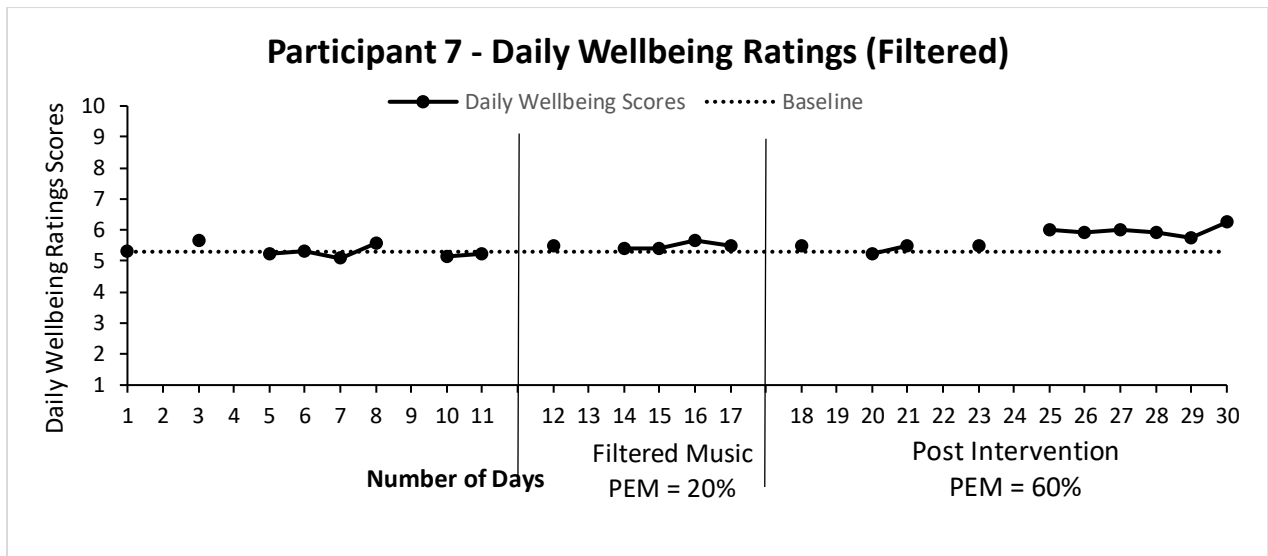
Lily's total scores on the DASS-21 (Table 11) decreased from pre- to post-intervention. Her scores on PA remained almost similar from pre- to post-intervention however, there was a substantial decrease in her NA scores. Lily's scores on the BBCSS auditory subscale increased from pre-intervention to post-intervention however, returned to almost a similar level as pre-intervention. Her NPSS scores increased from pre-intervention to post-intervention and then returned to almost a similar level as pre-intervention (Table 11).

After finishing the follow-up for the Unfiltered conditions, Lilly participated in the filtered music condition. Consequently, she was aware that she was receiving the filtered music intervention.

Her DWR scores (Figure 9) showed no consistent pattern of change in the daily well-being scores comparing baseline to intervention and post-intervention periods as a result of listening to unfiltered music. ($PEM_{F7} = 20\%$; $PEM_{PIF7} = 60\%$).

Figure 9

Daily Wellbeing Ratings for Participant 7 by Days for Filtered Music Conditions.



Note. PEM_{F7} = Percentage exceeding the median for Unfiltered music intervention for participant 7; PEM_{PIF7} = Percentage exceeding the median for post-intervention for participant 7. The data is missing for day 2, 4, 9, 13, 19, 22, 24.

Table 12

Scores on Various Measures for Participant 7 Across Time Points in Filtered Music Listening Conditions.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS Total
Pre- Intervention	8	1	13	22	30	19	35	42.3
Post Intervention	8	1	10	19	31	20	41	43.7
Follow up	2	2	7	11	36	22	47	45.3

Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain-Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Lilly's total score on the DASS-21 decreased from pre-intervention to follow-up. Her scores on the PANAS positive and negative subscale remained almost similar from pre- to post-intervention. Lilly's NPSS scores marginally increased consistently from pre- to post-intervention and then to follow-up. Her scores showed an increase in auditory hypersensitivity from pre-intervention to follow-up.

Participant 8 "Holly"

Holly initially received unfiltered music intervention and took 11 days to finish five hours of listening to unfiltered music. During this study, Holly went through a significant distressing life event so couldn't complete her daily well-being rating regularly. Her daily well-being rating data is missing from the listening intervention phase and the follow-up phase, hence couldn't be interpreted. Holly did complete her data for enrolment, pre-intervention, post-intervention and follow-up; hence, it is shown here in Table 13.

Table 13

Scores on Various Measures for Participant 8 Across Time Points in Unfiltered Music Listening Conditions.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS Total
Enrolment	15	15	16	46	37	33	48	38.3
Pre- Intervention	18	17	14	48	21	44	52	21.7
Post Intervention	19	18	17	44	29	46	52	24.3

Follow up	10	12	10	32	27	36	45	23.7
------------------	----	----	----	----	----	----	----	------

Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain-Body Center Sensory Scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Holly's DASS-21 total scores decreased from pre- to post-intervention and then to follow-up. (Table 13).

Holly's scores on the PANAS positive scale increased from pre-intervention to post-intervention. Her negative affect subscale scores showed irregular patterns as they increased from pre- to post-intervention and then decreased at the time of follow-up. Holly's scores on auditory hypersensitivity remained unchanged from pre- to post-intervention and then decreased and ended up being slightly lower than enrolment scores (Table 13). Holly's post-intervention and follow-up NPSS scores increased slightly, when compared to her pre-intervention scores however, remained lower than her enrolment scores.

Holly requested to receive filtered music intervention when she discovered that she received unfiltered music. So, she was offered the filtered music intervention.

However, her data is missing for PANAS, and BBCSS for pre-intervention, and complete data is missing for follow-up (Table 14).

Table 14

Scores on Various Measures for Participant 8 in the Filtered Music Conditions.

Time Point	DASS Depression	DASS Anxiety	DASS Stress	DASS Total	PANAS Positive	PANAS Negative	BBCSS Auditory	NPSS Total
Pre- Intervention	20	15	14	49	Missing data	Missing data	Missing data	21.7

Post Intervention	2	8	1	11	33	14	30	44.7
Follow up	Missing data	Missing data	Missing data	Missing data	Missing data	Missing data	Missing data	Missing data

Note. PANAS = Positive and Negative Affect Schedule; BBCSS = Brain-Body Center Sensory scales; DASS = Depression, Anxiety, and Stress Scales; NPSS = Neuroception of Psychological Safety Scale.

Holly's DASS total scores substantially reduced from pre-intervention to post-intervention. Her NPSS scores also substantially increased from pre- to post-intervention.

Overall Effectiveness

The Reliable Change criterion was calculated for each measure (Table 3) and compared against each participant's difference in Post – Pre-intervention scores to see the overall effectiveness of the intervention. These results are summarised in Table 16. In this table, the significant change in the expected direction is shown as a plus sign (+), a significant change in the negative direction is shown as a minus sign (-), and lastly no significant change is shown as a zero (0).

The DASS-21 scores did not change substantially in most participants during filtered music intervention. Only one participant showed a substantial increase in positive affect following the filtered music intervention whereas two participants showed a consistent increase in their negative affect. However, a substantial decrease in negative affect and a substantial increase in positive affect was noticed in two different participants following the unfiltered music intervention. Most participants showed no

substantial change in their NPSS scores following the filtered or unfiltered music intervention.

Table 15

Summarised Reliable Change using Post – Pre-intervention Differences on Each Measure for All Participants.

Participants		1	2	3	4	5	6		7		8	
		(F)	(F)	(F)	(F)	(UF)	(UF)	(F)	(UF)	(F)	(UF)	(F)
DASS-21 (RC>7.08)		0	0	0	0	0	0	0	0	0	0	+
PANAS	PA (RC>7.08)	+	0	0	0	0	+	0	0	0	+	Missin g
	NA (RC>6.33)	0	0	-	-	+	0	0	+	0	0	Missin g
NPSS (RC>9.20)		0	0	0	0	0	0	0	0	0	0	+

Note. UF = unfiltered music; F = filtered music; RC = Reliable Change; + =

Difference (Post – Pre-intervention scores) is more than the reliable change in the expected direction; - = difference is more than reliable change in the unfavourable direction; No = No reliable change; 0 = no change; DASS-21 = Depression, Anxiety, and Stress Scales; D = Depression; A = Anxiety; S = Stress; PANAS = Positive and Negative Affect Schedule; PA = Positive Affect; NA = Negative Affect; NPSS = Neuroception of Psychological Safety Scale.

Chapter 4: Discussion

The current study examined the impact of filtered music intervention on self-reported auditory hypersensitivity, well-being, and distress levels. Using a single-subject design, the study included eight participants and compared outcomes with those from non-filtered music conditions.

Results showed that the filtered music intervention was not associated with any substantial changes to the daily well-being ratings during or after the intervention for six out of seven participants. One participant showed a moderate increase in her DWR scores during the filtered music intervention; however, the effects did not last post-intervention. The SSP training and promotional materials describe that the effects of the intervention persist for some time following the intervention period. If the intervention had been effective, then we would expect the positive effects to continue. Six out of seven participants who received the filtered music intervention showed no reliable change in their overall distress levels as measured by DASS-21 from pre-intervention to post-intervention. Only one participant showed a reliable reduction in her DASS-21 scores following filtered music intervention; however, she had reported significant stresses that occurred during the treatment phase and were resolved by the time of follow-up. Therefore, it is not clear that the improvement was related to the intervention. None of the participants in the unfiltered music condition showed any reliable change on the DASS-21.

Scores on PANAS positive affect increased from pre-intervention to post-intervention for only one out of six participants (data missing for one participant) during filtered music intervention indicating increased positive engagement with the environment. Nevertheless, the scores on PANAS negative affect also increased significantly for two out of six participants (missing data for one participant) during the filtered music

conditions. In the unfiltered music conditions, two out of four participants showed a significant increase in their positive affect. In addition to this, another two participants showed a significant reduction in negative affect from pre-intervention to post-intervention following unfiltered music intervention. Overall, filtered music was no better than unfiltered music in reducing distress levels.

NPSS scores showed no reliable change from pre-intervention to post-intervention for six out of seven participants for filtered intervention. Only one participant showed a substantial increase in her perception of psychological safety following filtered music condition. There wasn't any reliable change in NPSS scores in the unfiltered conditions.

Of the seven participants who received filtered music, two improved on auditory hypersensitivity, three declined and Two others showed minimal change. This is an unexpected finding and could be due to participants being more aware of their hypersensitivity during the study. At the time of follow-up, before disclosing the type of music they received, the participants were asked if the music intervention reduced their auditory hypersensitivity and enhanced their well-being. Six out of seven participants reported that the filtered music did not reduce their auditory hypersensitivity. One participant answered yes to a decrease in their auditory hypersensitivity. Two participants reported finding music helpful in enhancing their well-being and sense of safety while others either answered no or were unsure. Most participants reported enjoying the music. They reported appreciating the time set aside for music and found listening to it relaxing.

Overall, current results are inconsistent with previous research (Porges et al., 2014), which found that filtered music reduced auditory hypersensitivity in children with ASD

when contrasted with the unfiltered music conditions. This study did not find any consistent evidence that the SSP reduced auditory hypersensitivity. This study did not find any consistent evidence that the SSP reduces auditory hypersensitivity in our participants.

Another study that explored the effects of SSP on adults (21 to 44 years old) with ASD (Kawai et al., 2023) found no significant improvement in Adolescent/Adult Sensory Profile (A/ASP) in pre- and post-intervention scores. Similar to our study, participants in this study listened to the first and last sessions of SSP music in the lab and the in-between sessions at home. However, each listening session involved listening to 60 min of music which differed from our study as we had varying session durations each day depending on participants' tolerance of the music and availability. The measure for sensory sensitivity used in this study (A/ASP) differed from the one used in our research (BBCSS). This study (Kawai et al., 2023) reported significant effects only on the family-reported, Social Awareness subscale of the Social Responsiveness Scale, second edition (SRS-2) following SSP intervention. Lastly, there was an absence of control conditions in this study, so the caregiver impressions could be influenced by expectations or demand characteristics.

Another study involving both children and adults investigated the impact of SSP on sensory sensitivities and observed a reduction in auditory hypersensitivities, which persisted at the four-week follow-up (Heilman et al., 2023). Although the BBCSS was used to measure sensory sensitivities in this study, data were collected using the parents'/caregivers' version of the assessment for participants aged 18 or younger and those with limited language abilities. Even though this study had the flexibility for participants to listen to music at home/clinic/school, each participant listened to an

hour of music each day that differed from our per-day listening durations. Also, there were no unfiltered control conditions and the participants in this study had more disability as compared to our sample.

Overall, the contradictory findings in our study could be due to the inconsistent duration of the music, the adult sample that included participants with or without ASD diagnosis, and the use of self-report measures. Also, some participants in our study showed clinically significant levels of distress on DASS-21 at the time of enrolment and pre-intervention. Some of these participants reported no diagnosed mental health history but significant life stressors such as exams & conflicts in relationships.

Despite having a stable daily well-being rating, most participants' scores in our study changed from enrolment to the pre-intervention stage across most measures, despite not starting the intervention. This change could be attributed to several factors such as reliability in answering the questionnaire, and the Hawthorne effect (McCambridge, Witton & Elbourne, 2014), where individuals modify their behaviour because they know they are being observed or are part of a study. Participants might have become more attentive or engaged, which could have influenced their scores independently of the actual intervention. This could also be due to time and fluctuating motivation as for some participants, there was a long gap between enrolment and pre-intervention due to their scheduling difficulties.

Strengths

Our study presented several strengths. We studied the effects of filtered music conditions in remote delivery, a real-life setting where participants chose to listen to the music in the comfort of their homes under the guidance of the researcher who was trained in the delivery of SSP. This is the way it is being used clinically in many locations. Secondly, we had unfiltered music conditions to compare if the effects

were unique to the filtration of the music. Next, the SSP is prescribed for all age groups with or without ASD for different mental health problems whereas the effects were mainly studied on children with ASD. There is a gap in the literature about the impact of SSP on the adult population. Our study tried to fill the gap in the literature by studying the effects of SSP on adults with self-reported auditory hypersensitivity.

Limitations

There were several limitations in this study. Firstly, the sample size was too small to analyse the data statistically so caution needs to be taken in generalising the results. Secondly, this study involved a mixed sample that included both individuals with ASD (two participants- one each in filtered and unfiltered listening conditions) and those with neurotypical presentations. We focused on auditory hypersensitivity as an inclusion criterion rather than diagnosis of ASD, and the participants were relatively high-functioning independent adults, which differed from most studies. Due to this heterogeneity, it was inappropriate to draw overall conclusions. Thirdly, some psychometric tools such as BBCSS, and NPSS used in this study were fairly new, developed overseas, and had limited information available on their psychometric properties. Due to the lack of normative data for these tools, it was not easy to contextualise and compare findings with the existing literature.

The study's methodology also had several limitations. Scheduling difficulties led to some participants experiencing a long delay between enrolment and the start of the intervention. The DWR began on the enrolment day and continued until the follow-up day. Delays in starting the intervention extended the period for recording DWR, which might have caused participant fatigue. Additionally, longer intervention phases (due to the inability to tolerate the music in high doses) for some participants could have

further contributed to fatigue potentially affecting their ratings and leading to missing data. Missing data presented a challenge in the study, making data analysis for some participants more difficult and potentially influencing the interpretation and validity of the results. Conducting most of the study remotely, within participants' home environments, introduced variability in the listening conditions during the intervention phase. This also limited control over external factors such as distractions and interruptions. Ensuring adherence to the intervention protocol remotely was challenging, particularly in verifying that the participants followed the prescribed conditions—such as using external headphones without noise-cancelling features, maintaining a quiet and relaxing environment, and avoiding multitasking with stressful activities. These factors could potentially affect the validity of the findings although this is the typical setting for this intervention in general clinical practice. Additionally, remote settings may limit the opportunity for real-time interactions and support from researchers, which is sometimes needed. Listening sessions conducted virtually (using Zoom/ Teams/Skype) would have been a helpful alternative that would have addressed some of the limitations of remote delivery. This option was offered to participants however, all participants chose to listen as they pleased rather than choosing a fixed schedule.

We had plans to measure Heart Rate Variability using a portable device. However, due to the device malfunctioning, the data was not reliable. Hence, we couldn't use the data for analysis. Future research would benefit from including psychophysiological measures.

Future Direction

For future research, both qualitative and quantitative studies are required to evaluate the impact and subjective experience of SSP on adult participants with auditory

sensitivities with or without ASD. A randomised controlled trial with a sufficiently large sample size, conducted by independent researchers, will contribute to our understanding of causality and help to evaluate the effectiveness of this intervention by reducing the impact of confounding variables. This will lead to robust and generalisable findings. Additionally, it would be beneficial to use objective measures to record changes in auditory hypersensitivity. Alternatively, instruments with strong psychometric properties should be used to ensure the reliability and validity of the data. The SSP is being promoted as an intervention for a variety of clinical groups including adults with trauma, anxiety, etc. and it needs to be tested systematically with these groups.

On the other hand, a qualitative study can provide deeper insights into participants' experiences. The subjective reports of participants in this study did not suggest that they saw SSP as helpful. Using interviews and focused groups, researchers can gain a richer understanding of how SSP impacts participants' daily lives, their subjective sense of improvement or non-improvement, and any challenges they may encounter. Integrating a mixed-method approach could provide a thorough exploration of both statistical significance and personal relevance, leading to more nuanced conclusions and practical recommendations for future research and application.

The SSP training recommends therapist discretion to titrate the music depending on the client's reaction to the music. However, most published studies involved hour-long listening sessions each day (Porges et.al., 2014, Heilman et al., 2023, Kawai et al., 2023). Further research is required to study the effects of smaller or varied listening durations with & without skipping sessions.

For future studies, if the intervention is planned to be administered remotely then a therapist's virtual presence would be beneficial to ensure standardised delivery. Lastly, randomly assigned unfiltered music control conditions are strongly recommended with a large enough sample size as it would help isolate the effects of filtered music intervention.

Conclusion

This study aimed to evaluate the effectiveness of the remotely administered Safe and Sound Protocol (SSP) on auditory hypersensitivities and overall well-being in adults within a real-world context. The findings revealed no significant difference in self-reported auditory hypersensitivities or improvements in well-being. Some prior studies, mostly small and uncontrolled clinical trials (Heilman et al., 2023; Kawai et al., 2023; Porges et al., 2013) have found positive outcomes, but this study brings into question whether this intervention is effective for adults with auditory hypersensitivities. The SSP, grounded in Polyvagal Theory (PVT), is recommended for various mental health issues across the lifespan. However, its efficacy across different populations remains unclear. Therefore, further research is necessary, involving independent investigators and employing both qualitative and RCT methodologies, to clarify the effects of SSP.

References

Antony, M. M., Bieling, P. J., Cox, B. J., Enns, M. W., & Swinson, R. P. (1998). Psychometric properties of the 42-item and 21-item versions of the Depression Anxiety Stress Scales in clinical groups and a community sample. *Psychological Assessment*, *10*(2), 176-181. <https://doi.org/10.1037/1040-3590.10.2.176>

Blampied, N. M. (2022). Reliable change and the reliable change index: Still useful after all these years? *the Cognitive Behaviour Therapist*, *15*, Article e50. <https://doi.org/10.1017/S1754470X22000484>

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct Validity, Measurement Properties and Normative Data in a Large Non-Clinical Sample. *British Journal of Clinical Psychology*, *43*, 245-265. <https://doi.org/10.1348/0144665031752934>

Czarnecka, Emilia & Lachowska, Magdalena. (2020). Auditory hypersensitivity – definition, etiology, etiopathogenesis, diagnostic and therapeutic possibilities. *Polski Przegląd Otorynolaryngologiczny*. *9*. 27-34. [10.5604/01.3001.0014.1214](https://doi.org/10.5604/01.3001.0014.1214).

de Boer, A. G. E. M., Van Lanschot, J. J. B., Stalmeier, P. F. M., Van Sandick, J. W., Hulscher, J. B. F., de Haes, J. C. J. M., & Sprangers, M. A. G. (2004). Is a single-item visual analogue scale as valid, reliable and responsive as multi-item scales in measuring quality of life? *Quality of Life Research*, *13*(2), 311-320. <https://doi.org/10.1023/B:QURE.0000018499.64574.1f>

Feinstein, J. S., Khalsa, S. S., Yeh, H., Al Zoubi, O., Arevian, A. C., Wohlrab, C., Pantino, M. K., Cartmell, L. J., Simmons, W. K., Stein, M. B., & Paulus, M. P. (2018). The Elicitation of Relaxation and Interoceptive Awareness Using Floatation Therapy in

Individuals With High Anxiety Sensitivity. *Biological psychiatry. Cognitive neuroscience and neuroimaging*, 3(6), 555–562. <https://doi.org/10.1016/j.bpsc.2018.02.005>

Heilman, K. J., Heinrich, S., Achermann, M., Nix, E., Kyuchukov, H. (2023). Effects of the Safe and Sound Protocol (SSP) on sensory processing, digestive function and selective eating in children and adults with autism: a prospective single-arm study. *Journal on Developmental Disabilities*, 20(1).

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, 44(2), 227–239. <https://doi.org/10.1348/014466505X29657>

Heubeck, B. G., & Wilkinson, R. (2019). Is all fit that glitters gold? Comparisons of two, three and bi-factor models for Watson, Clark & Tellegen's 20-item state and trait PANAS. *Personality and Individual Differences*, 144, 132–140. <https://doi.org/10.1016/j.paid.2019.03.002>

Jacobson, N. S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology*, 59(1), 12–19. <https://doi.org/10.1037/0022-006X.59.1.12>

Kawai, H., Kishimoto, M., Okahisa, Y., Sakamoto, S., Terada, S., & Takaki, M. (2023). Initial Outcomes of the Safe and Sound Protocol on Patients with Adult Autism Spectrum Disorder: Exploratory Pilot Study. *International journal of environmental research and public health*, 20(6), 4862. <https://doi.org/10.3390/ijerph20064862>

Kolacz, J., Raspa, M., Heilman, K. J., & Porges, S. W. (2018). Evaluating Sensory Processing in Fragile X Syndrome: Psychometric Analysis of the Brain Body Center

Sensory Scales (BBCSS). *Journal of autism and developmental disorders*, 48(6), 2187–2202. <https://doi.org/10.1007/s10803-018-3491-3>

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy*, 33(3), 335–343. [https://doi.org/10.1016/0005-7967\(94\)00075-U](https://doi.org/10.1016/0005-7967(94)00075-U)

Lovibond, S. H., & Lovibond, P. F. (1995). *Depression Anxiety Stress Scales (DASS--21, DASS--42)* [Database record]. APA PsycTests. <https://doi.org/10.1037/t01004-000>

Lucker, J. R. (2013). Auditory Hypersensitivity in Children With Autism Spectrum Disorders. *Focus on Autism and Other Developmental Disabilities*, 28(3), 184-191. <https://doi.org/10.1177/1088357613475810>

Lucker, J. R., & Doman, A. (2015). Neural Mechanisms Involved in Hypersensitive Hearing: Helping Children with ASD Who Are Overly Sensitive to Sounds. *Autism Research and Treatment*, 2015, 369035. <https://doi.org/10.1155/2015/369035>

Ma, H. (2006). An alternative method for quantifying synthesis of single-subject research: Percent of data points exceeding the median. *Behavior Modification*, 30, 598–617.

Matsuzaki, J., Kagitani-Shimono, K., Sugata, H., Hirata, M., Hanaie, R., Nagatani, F., Tachibana, M., Tominaga, K., Mohri, I., & Taniike, M. (2014). Progressively increased M50 responses to repeated sounds in autism spectrum disorder with auditory hypersensitivity: A magnetoencephalographic study. *PloS one*, 9(7), e102599. <https://doi.org/10.1371/journal.pone.0102599>

McCambridge, J., Witton, J., & Elbourne, D. R. (2014). Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *Journal of clinical epidemiology*, 67(3), 267–277. <https://doi.org/10.1016/j.jclinepi.2013.08.015>

Medvedev, O. N. (2023). Depression Anxiety Stress Scales (DASS-21) in international contexts. In (Eds.) *International Handbook of Behavioral Health Assessment* (pp. 1-10). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-89738-3_15-1

Merz, E. L., Malcarne, V. L., Roesch, S. C., Ko, C. M., Emerson, M., Roma, V. G., & Sadler, G. R. (2013). Psychometric properties of Positive and Negative Affect Schedule (PANAS) original and short forms in an African American community sample. *Journal of affective disorders*, 151(3), 942–949. <https://doi.org/10.1016/j.jad.2013.08.011>

Morton, L., Cogan, N., Kolacz, J., Calderwood, C., Nikolič, M., Bacon, T., Pathe, E., Williams, D., & Porges, S. (2021). *Neuroception of Psychological Safety Scale (NPSS) Manual and Scoring Guide*. Retrieved from the Traumatic Stress Research Consortium (TSRC) website: <https://www.traumascience.org/neuroception-of-safety-scale>

Morton, L., Cogan, N., Kolacz, J., Calderwood, C., Nikolic, M., Bacon, T., Pathe, E., Williams, D., & Porges, S. W. (2022). "A new measure of feeling safe: Developing psychometric properties of the Neuroception of Psychological Safety Scale (NPSS)": Correction. *Psychological trauma : theory, research, practice and policy*, 16(4), 709. <https://doi.org/10.1037/tra0001374>

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology*, 32(4), 301-318.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, 74(2), 116–143. <https://doi.org/10.1016/j.biopsycho.2006.06.009>

Porges S. W. (2009). The polyvagal theory: new insights into adaptive reactions of the autonomic nervous system. *Cleveland Clinic journal of medicine*, 76 Suppl 2(Suppl 2), S86–S90. <https://doi.org/10.3949/ccjm.76.s2.17>

Porges, S. W. (2012). The Brain-Body Center Sensory Scales (BBCSS). The Brain-Body Center. University of Illinois at Chicago.

Porges S. W. (2022). Polyvagal Theory: A Science of Safety. *Frontiers in integrative neuroscience*, 16, 871227. <https://doi.org/10.3389/fnint.2022.871227>

Porges S. W. (2023). The vagal paradox: A polyvagal solution. *Comprehensive psychoneuroendocrinology*, 16, 100200. <https://doi.org/10.1016/j.cpniec.2023.100200>

Porges, S. W., & Lewis, G. F. (2010). The polyvagal hypothesis: Common mechanisms mediating autonomic regulation, vocalisations and listening. In S. M. Brudzynski (Ed.), *Handbook of ultrasonic vocalisation: A window into the emotional brain* (pp. 2334). Elsevier Academic Press. <https://doi.org/10.1016/B978-0-12-809600-0.00003-2>

Porges, S. W., Macellaio, M., Stanfill, S. D., McCue, K., Lewis, G. F., Harden, E. R., Handelman, M., Denver, J., Bazhenova, O. V., & Heilman, K. J. (2013). Respiratory sinus arrhythmia and auditory processing in autism: modifiable deficits of an integrated social engagement system?. *International journal of psychophysiology : official journal of the International Organization of Psychophysiology*, 88(3), 261–270.

Porges, S. W., Bazhenova, O. V., Bal, E., Carlson, N., Sorokin, Y., Heilman, K. J., Cook, E. H., & Lewis, G. F. (2014). Reducing auditory hypersensitivities in autistic spectrum disorder: preliminary findings evaluating the listening project protocol. *Frontiers in pediatrics*, 2, 80. <https://doi.org/10.3389/fped.2014.00080>

Rajabalee, N., Kozłowska, K., Lee, S. Y., Savage, B., Hawkes, C., Siciliano, D., Porges, S. W., Pick, S., & Torbey, S. (2022). Neuromodulation Using Computer-Altered Music to Treat a Ten-Year-Old Child Unresponsive to Standard Interventions for Functional Neurological Disorder. *Harvard review of psychiatry*, 30(5), 303–316.

Roemer, A., & Medvedev, O. (2023). Positive and Negative Affect Schedule (PANAS). In (Eds.) *Encyclopedia of Quality of Life and Well-Being Research* (pp. 1-10). https://doi.org/10.1007/978-3-030-77644-2_86-1

Rogowski, M., Damiao, J. A., Cavaliere, C., Rust, N., Lopez, A., Marash, R., & Zdrodowski, A. (2024). An exploratory study of the Safe & Sound Protocol in young children with autism. *American Journal of Occupational Therapy*, 78(Supplement 2), 7811500332p1. <https://doi.org/10.5014/ajot.2024.78S2-PO332>

Şen, N., & Sen, S. (2019). Calculation of effect size in single-subject experimental studies: Examination of non-regression-based methods. *Journal of Measurement and Evaluation in Education and Psychology*, 10(1), 30-48. <https://doi.org/10.21031/epod.419625>

Serafini, K., Malin-Mayor, B., Nich, C., Hunkele, K., & Carroll, K. M. (2016). Psychometric properties of the Positive and Negative Affect Schedule (PANAS) in a heterogeneous sample of substance users. *The American journal of drug and alcohol abuse*, 42(2), 203–212. <https://doi.org/10.3109/00952990.2015.1133632>

Squillace, M., Lopez, A., & Cohn, K. (2022). Social outcomes of a child with autism spectrum disorder following a listening protocol. *Journal of Occupational Therapy, Schools, & Early Intervention*. <https://doi.org/10.1080/19411243.2022.2156425>

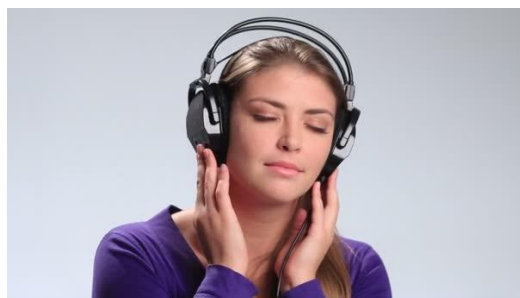
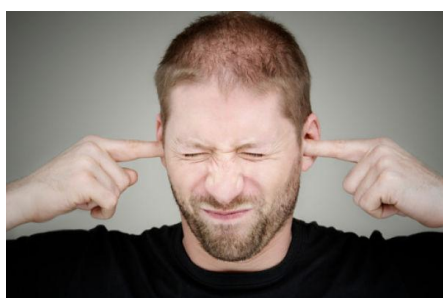
Tindle, J., & Tadi, P. (2020). Neuroanatomy, parasympathetic nervous system. In *StatPearls* (Updated 2020 Nov 15). StatPearls Publishing. Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK553141/>

Watson, D., & Clark, L. A. (1994). The PANAS-X: Manual for the positive and negative affect schedule-expanded form. *Unpublished manuscript, University of Iowa*.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS Scales. *Journal of Personality and Social Psychology*, 47, 1063–1070.

Appendix A

Effects of filtered music on adults with high sensitivity to sound



Volunteers needed for a research study

We are looking for volunteers for a study testing the effects of a special type of filtered music to enhance one's sense of safety and reduce hypersensitivities among people who are bothered by sounds.

- **Do you notice yourself reacting negatively to certain sounds?**
- **Feel overwhelmed by noises?**
- **Do you have hearing hypersensitivities or auditory processing difficulties?**

You will be required to:

Listen to 5 hours of music over 5-10 days.

Complete a brief daily rating of your mood throughout the study.

Complete some questionnaires and give us your feedback.

Interested?

For more information contact: pk266@students.waikato.ac.nz or 0211156052

This research project has been approved by the Human Research Ethics Committee (Health) of the University of Waikato under HREC(Health)2023#08. Any questions about the ethical conduct of this research may be addressed to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Appendix B

Effects of filtered music on people with high sensitivity to sounds Information for Participants



Thank you for your interest in participating in our study. This study is an initial trial to look at the effect of a special type of filtered music on reducing one's hearing hypersensitivities and sense of safety and relaxation. This study will serve as a Master's thesis for Praveen Khatri, a student of the Clinical Psychology Programme at the University of Waikato, supervised by Dr. Carrie Barber, a senior lecturer in psychology at the University of Waikato.

Hearing sensitivity is a commonly reported problem. Some people are more sensitive to sounds than others, and this kind of sensitivity can be frustrating and disturbing, particularly in noisy environments. People with hearing sensitivity seem to process sound differently, which can also affect their emotional state and sense of safety.

The filtered music used in this study trains the middle ear muscles to tune into the cues of safety as signalled by the frequencies of the human voice. The music is adapted and progressively trains the muscles and the nervous system over the 5 hours of the treatment. Typically, this is delivered 30-60min per day for 5-10 days consecutively depending on the individual's tolerance and schedule.

Study Procedure

If you participate in this study, you will be asked to complete some questionnaires about your background, current mood, sensory sensitivities, and sense of safety, which will take 15-20 minutes to complete. Your heart rate will also be measured as part of the study with a small portable finger-based device. We will set up a time (at the time of day you choose) when you'll get an e-mail each day that asks you to answer nine questions about your sleep the night before and several aspects of well-being such as muscle tension, mood, and energy. This typically takes at most 2-3 minutes to complete on your phone or computer.

After about a week of completing daily ratings, we will review your average ratings to see if they form a stable baseline; you may be asked to continue for a few more days, particularly if you've had significant ups or downs that may be affecting how you feel. This is so we can see more clearly the effects of the intervention.

Once your ratings are relatively stable, you will be randomly assigned to either a filtered or non-filtered music group. In either case, you will be invited to a psychology department room (K.3.17) and after orientation will be given headphones to listen to the music. Praveen will stay with you throughout to monitor your reaction and provide support if required. You are also welcome to bring a support person who has a calming effect on you.

There will be an option for a break in the middle of listening if it is required. On the basis of how you find the music on day one, we will decide whether to do an hour each day for five

days or for half an hour each day for ten days. We will measure your heart rate before and after each session. Your feedback about the music will also be taken regularly during this time. After your final listening session, you will continue your daily ratings for two weeks. Then we will organise a meeting to get your feedback about your overall experience, and to do the questionnaires again. After this, we will let you know whether you were in the filtered or unfiltered group. If you were in the unfiltered group, you will be offered the option of repeating the process with the filtered music.

All information you provide in the study will be kept confidential; your name **will not** be stored with any of the data collected. The only exception would be if we were concerned for your immediate health or safety; in this case, we would encourage you to talk with your healthcare provider, but in an emergency, we might need to contact them directly. When you respond to the surveys, we will use a unique identifier, so that your name will not be in the data files. Data will be kept in password-protected computer files for at least five years after the study is completed.

Results from this study will contribute to Praveen Khatri's Master's thesis and may be published in a journal article and/or professional conference presentation. We will also produce a brief summary of the findings, which we will send to you if you wish. You will not be identifiable in any reports or presentations connected with the study.

You are always free to decline to answer any questions or to withdraw from the study at any point up to 3 weeks after completing the intervention (listening sessions). We hope that participating in the study will be helpful to you in terms of reducing your auditory hypersensitivities and feeling more relaxed and safer, but we cannot know for sure whether you will benefit from either of the interventions. If you have any questions about this research, please feel free to contact Dr Carrie Barber (Supervisor) at carrie.barber@waikato.ac.nz, or 07-8379221, or Praveen Khatri at pk266@students.waikato.ac.nz or 0211156052.

This research project has been approved by the Human Research Ethics Committee (Health) of the University of Waikato under HREC(Health)2023#08. Any questions about the ethical conduct of this research may be addressed to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Appendix C



Research project: Effects of filtered music on people with high sensitivity to sound.

PARTICIPANT CONSENT FORM

(A completed copy of this form should be retained by both the researcher and the participant)

Please complete the following checklist. Tick the appropriate box for each point.	YES	NO
1. I have read the Participant Information Sheet (or it has been read to me) and I understand it.		
2. I have been given sufficient time to consider whether or not to participate in this study.		
3. I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.		
4. I understand that participating in this study is voluntary (my choice) and that I may withdraw from the study at any time up to 3 weeks after completing the intervention without penalty.		
5. I have the right to decline to participate in any part of the research activity.		
6. I know who to contact if I have any questions about the study in general.		
7. I understand that the information supplied by me could be used in future academic publications.		
8. I understand that my participation in this study is confidential and that no material which could identify me personally will be used in any reports on this study.		
9. I wish to receive a summary of the findings.		

Declaration by participant:

I agree to participate in this research project and I understand that I may withdraw at any time up to 3 weeks after completing the intervention. Please circle: **Yes**

No

Participant's name (Please print): _____

Signature: _____ **Date:** _____

Declaration by the Researcher:

I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it. I believe that the participant understands the study and has given informed consent to participate.

Researcher's Name: Praveen Khatri

Signature: _____ **Date:** _____

This research project has been approved by the Human Research Ethics Committee (Health) of the University of Waikato under HREC(Health)2023#08. Any questions about the ethical conduct of this research may be addressed to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Appendix D

Enrolment Questions

Q1 ID: Please use the first 2 initials from your first and last name and the last 3 digits of your mobile number.

Q2 Demographic information

Age (1) _____

Gender (2) _____

Ethnicity (3) _____

Q3 How much education you have completed?

No formal qualifications (1)

High School Qualification (2)

Some tertiary studies but no qualification (3)

Tertiary qualification (4)

Postgraduate qualification (5)

Q4 Your highest qualification that you have completed?

Q5 Are you currently taking any medications regularly, either prescribed or pharmacy medications? If yes, then please list:

6 Your preferred mode of contact:

Mobile (1) _____






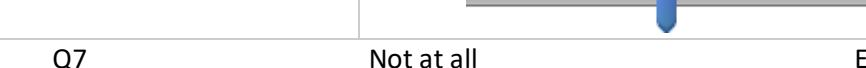
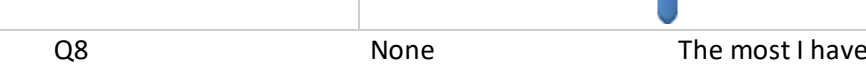
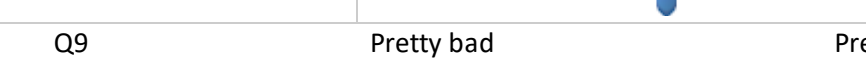

Email (2) _____

Appendix E

Study Measures

E.1 Daily Wellbeing ratings

For each of the following questions, please use the slider to rate each item; please be sure you've touched or moved the slider and it darkens from grey to black to make sure your response is registered, even if you leave it at the initial level.

Q1	Very poorly 1 2 3 4 5 6 7 8 9 10 Very well
How did you sleep last night? ()	
Q2	Not at all 1 2 3 4 5 6 7 8 9 10 Extremely
How relaxed do you feel right now? ()	
Q3	None 1 2 3 4 5 6 7 8 9 10 The most I have ever felt
How much muscle tension or tightness do you feel right now? ()	
Q4	Not at all 1 2 3 4 5 6 7 8 9 10 Extremely
How stressed or anxious do you feel right now? ()	
Q5	Not at all 1 2 3 4 5 6 7 8 9 10 Extremely
How sad, down or depressed do you feel right now? ()	
Q6	Not at all 1 2 3 4 5 6 7 8 9 10 Extremely
How content or peaceful do you feel right now? ()	
Q7	Not at all 1 2 3 4 5 6 7 8 9 10 Extremely
How refreshed do you feel right now? ()	
Q8	None 1 2 3 4 5 6 7 8 9 10 The most I have ever felt
How much energy do you have right now? ()	
Q9	Pretty bad 1 2 3 4 5 6 7 8 9 10 Pretty good
In general, right now, how do you feel? ()	

E.2 Depression Anxiety Stress Scale (DASS-21)

Please read each statement and select the option that indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

- 0 Did not apply to me at all
- 1 Applied to me to some degree, or some of the time
- 2 Applied to me to a considerable degree or a good part of time
- 3 Applied to me very much or most of the time

1 (s)	I found it hard to wind down	0	1	2	3
2 (a)	I was aware of dryness of my mouth	0	1	2	3
3 (d)	I couldn't seem to experience any positive feeling at all	0	1	2	3
4 (a)	I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5 (d)	I found it difficult to work up the initiative to do things	0	1	2	3
6 (s)	I tended to over-react to situations	0	1	2	3
7 (a)	I experienced trembling (e.g. in the hands)	0	1	2	3
8 (s)	I felt that I was using a lot of nervous energy	0	1	2	3
9 (a)	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10 (d)	I felt that I had nothing to look forward to	0	1	2	3
11 (s)	I found myself getting agitated	0	1	2	3
12 (s)	I found it difficult to relax	0	1	2	3
13 (d)	I felt down-hearted and blue	0	1	2	3
14 (s)	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15 (a)	I felt I was close to panic	0	1	2	3
16 (d)	I was unable to become enthusiastic about anything	0	1	2	3
17 (d)	I felt I wasn't worth much as a person	0	1	2	3
18 (s)	I felt that I was rather touchy	0	1	2	3
19 (a)	I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	0	1	2	3
20 (a)	I felt scared without any good reason	0	1	2	3
21 (d)	I felt that life was meaningless	0	1	2	3

E.3 Positive and Negative Affect Schedule (PANAS-SF)

Positive and Negative Affect Schedule (PANAS-SF)

Indicate the extent you have felt this way over the past week.		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 2	Distressed	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 3	Excited	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 4	Upset	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 5	Strong	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 6	Guilty	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 7	Scared	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 8	Hostile	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 9	Enthusiastic	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 10	Proud	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 11	Irritable	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 12	Alert	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 13	Ashamed	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 14	Inspired	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 15	Nervous	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 16	Determined	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 17	Attentive	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 18	Jittery	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 19	Active	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
PANAS 20	Afraid	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

E.4 Neuroception of Psychological Safety Scale – Generic Version (NPSS)

Neuroception of Psychological Safety Scale - Generic Version (NPSS-G)

Morton, L., Cogan, N., Kolacz, J., Calderwood, C., Nikolić, M., Bacon, T.,
 Pathe, E., Williams, D., Porges, S. (2021) ©



Please rate how well the following statements describe your feelings over the past week.

Strongly Disagree (score = 1), *Disagree* (score = 2), *Neither Agree or Disagree* (score = 3),
Agree (score = 4), *Strongly Agree* (score = 5).

1	I felt valued	1	2	3	4	5
2	I felt comfortable expressing myself	1	2	3	4	5
3	I felt accepted by others	1	2	3	4	5
4	I felt understood	1	2	3	4	5
5	I felt like others got me	1	2	3	4	5
6	I felt respected	1	2	3	4	5
7	There was someone who made me feel safe	1	2	3	4	5
8	There was someone that I could trust	1	2	3	4	5
9	I felt comforted by others	1	2	3	4	5
10	I felt heard by others	1	2	3	4	5
11	I felt like people would try their best to help me	1	2	3	4	5
12	I felt cared for	1	2	3	4	5
13	I felt wanted	1	2	3	4	5
14	I didn't feel judged by others	1	2	3	4	5
15	I felt able to empathise with other people	1	2	3	4	5
16	I felt able to comfort another person if needed	1	2	3	4	5
17	I felt compassion for others	1	2	3	4	5
18	I wanted to help others relax	1	2	3	4	5
19	I felt like I could comfort a loved one	1	2	3	4	5
20	I felt so connected to others I wanted to help them	1	2	3	4	5
21	I felt caring	1	2	3	4	5
22	My heart rate felt steady	1	2	3	4	5
23	Breathing felt effortless	1	2	3	4	5
24	My voice felt normal	1	2	3	4	5
25	My body felt relaxed	1	2	3	4	5
26	My stomach felt settled	1	2	3	4	5
27	My breathing was steady	1	2	3	4	5
28	I felt able to stay still	1	2	3	4	5
29	My face felt relaxed	1	2	3	4	5

E.5 The Brain Body Sensory Scales (BBCSS) – Self-report, Adult Form.

Auditory Processing

BBCSS 1 How often do you respond negatively to unexpected or loud noises (for example, hide or cringe at noise from ambulance, train, fire or car alarm, fireworks)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 2 How often do you become distracted, or have difficulty following verbal instructions when there is a lot of noise around?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 3 How often do you hold your hands over or plug your ears?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 4 How often do you not hear what others say (for example, you fail to pay attention to what others say)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 5 How often do you have trouble working with background noise (for example, air conditioner, traffic noises, airplanes)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 6 How often do you not respond when your name is called, even though you know your hearing is not a problem?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 7 How often are you unusually angry, frightened, or in pain when others cry or scream?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)

- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 8 How often do others have to speak loudly or get very close to your face to get your attention?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 9 How often are you unaware of continuous noise in the environment (for example, TV, stereo)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 10 How often are you overly aware, distracted, or disturbed by continuous noise in the environment (for example, TV, stereo)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 11 How often do you take a long time to respond when spoken to, even to familiar voices?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 12 How often do you startle easily at sound, compared to others, with loud or high-pitched noises (for example, vacuum, blender, fire alarms)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 13 How often are you distracted by sounds not normally noticed by other people (for example, air conditioning fans, trains or planes outside)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 14 How often do you respond negatively (i.e. become distracted or anxious) when entering places with continuous background noises (for example, grocery stores, schools, shopping malls)?

- Almost Always (1)
- Frequently/ Often (2)

- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

Visual Processing

BBCSS 15 How often are you bothered by bright lights after others' eyes have adapted to the same light?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 16 How often do you cover your eyes or squint?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 17 How often are you unable to tolerate bright lights?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)

Not Sure/ Not Applicable (5)

BBCSS 18 How often are you unable to tolerate flashing lights?

Almost Always (1)

Frequently/ Often (2)

Sometimes/ Occasionally (3)

Almost Never (4)

Not Sure/ Not Applicable (5)

BBCSS 19 How often do you get agitated when exposed to bright lights?

Almost Always (1)

Frequently/ Often (2)

Sometimes/ Occasionally (3)

Almost Never (4)

Not Sure/ Not Applicable (5)

BBCSS 20 How often are you sensitive to bright lights (for example, squint or close eyes)?

Almost Always (1)

Frequently/ Often (2)

Sometimes/ Occasionally (3)

Almost Never (4)

Not Sure/ Not Applicable (5)

BBCSS 21 How often are you sensitive to flashing lights (for example, squint or close eyes)?

Almost Always (1)

- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 22 How often do you hesitate to go outside when it's sunny?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 23 How often are you easily distracted by movement only you can see?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 24 How often are you easily distracted by movements of objects (i.e. mechanical objects or repetitive movements)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

Tactile Processing

BBCSS 25 How often are you distressed or overly-sensitive to tooth-brushing?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 26 How often are you distressed or overly-sensitive to face-washing?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 27 How often are you distressed or overly-sensitive to fingernail-cutting?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 28 How often are you distressed or overly-sensitive to hair-brushing?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)

- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 29 How often do you remove labels or tags from most clothing, or ask that they be removed?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 30 How often do you refuse to wear certain fabrics or find certain fabrics irritating?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 31 How often do you find certain garments are too tight, scratchy or irritating?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 32 How often do you prefer to not wear certain clothing items?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 33 How often do you resist hugging?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 34 How often do you react negatively or overly sensitively to hand-holding?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 35 How often do you react emotionally or overly sensitively to being touched?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 36 How often do you react emotionally or overly sensitively when touching very cold objects with your hands?

- Almost Always (1)
- Frequently/ Often (2)

- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 37 How often do you react emotionally or overly sensitively when very cold objects touch your face?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

Ingestion and Digestion

BBCSS 38 How often do you avoid certain tastes?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 39 How often do you resist certain textures of food?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 40 How often do you avoid certain food smells?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 41 How often do you resist certain temperatures of food?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)

- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 42 How often do you gag?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 43 How often do you vomit?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 44 How often do you have acid reflux?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 45 How often do you have excessive intestinal gas?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 46 How often are you constipated?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)

- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 47 How often do you experience stomach or intestinal cramping?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 48 How often do you have difficulty swallowing solid foods?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 49 How often do you suck on objects other than food (for example, pen, lip, own tongue)?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

BBCSS 50 How often do you eat (or want to eat) significantly less than you think is appropriate for your size or age?

- Almost Always (1)
- Frequently/ Often (2)
- Sometimes/ Occasionally (3)
- Almost Never (4)
- Not Sure/ Not Applicable (5)

Appendix F

Email for permission to use BBCSS

from: **Kolacz, Jacek** <jkolacz@iu.edu>
to: Praveen Khatri
<praveenkhatri10@gmail.com>
date: Mar 1, 2023, 3:59 AM
subject: RE: [External] Use of BBCSS for study

mailed-by: iu.edu

signed-by: iu.edu

security: Standard encryption (TLS) [Learn more](#)
: Important mainly because it was sent directly to you.

Kolacz, Jacek

Mar 1, 2023,
3:59 AM

to me

Hello Praveen-

Thank you for reaching out. It's terrific to hear that you are planning to conduct an SSP study. The BBCSS is free to use for all clinical, research, and educational purposes. I'm attaching the scale, scoring manual, and first psychometric paper.

If you have any questions please let me know.

Best wishes on your study,
Jacek

Jacek Kolacz, PhD

Research Assistant Professor
Department of Psychiatry and Behavioral Health
The Ohio State University Wexner Medical Center

Managing Director
The Traumatic Stress Research Consortium (TSRC)
The Kinsey Institute at Indiana University

Appendix G

Support services (for participants)

- Student Health and Services: Located by the Gate 1 carpark, Student Health Centre offers health and counselling services to all current University of Waikato students.
Phone: +64 7-838 4037
- Accessibility Services: The University of Waikato service to support students with impairments in reaching their full academic potential. It is located on level 2 of the student centre (opposite the entrance to the campus book shop).
Office hours: Monday - Friday 8.30am to 5pm Phone: 07 838 4711 or 07 838 4393
<https://www.waikato.ac.nz/students/accessibility-services>
Email: accessibilityservices@waikato.ac.nz
- Just a thought: Just a Thought is a free online mental health support tool, specifically designed for dealing with mild-to-moderate symptoms of anxiety and depression.
Website: <https://www.justathought.co.nz/>
- Misophonia Association: This organization provides support, education, and advocacy for people with misophonia, a condition characterized by strong negative reactions to specific sounds. Their website offers information on treatment options, support groups, and coping strategies.
Website: <https://www.misophonia-association.org/>
- The Hyperacusis Network: This organization offers a support group for people with hyperacusis (hypersensitivity to sounds) and related conditions, as well as information on treatment options and coping strategies.
Website: <https://www.hyperacusis.net/>
- Lifeline (0800) LIFELINE or (0800 543 354): 24-hour telephone counselling service
- 1737 Need to Talk: 24-hour free telephone counselling; free call or text 1737 any time.
- Youthline – 0800 37 66 33
- Crisis Assessment and Treatment Team (0800-50-50-50): Available 24-hours, 7 days per week for mental health emergencies.
- Altogether Autism: 0800 273 463 Website: <https://www.altogetherautism.org.nz/>
- ADHD New Zealand: <https://www.adhd.org.nz/>
- Support for learning disability: <https://www.speld.org.nz/>