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Editors

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Editorial

If not now…if only for others-invisible risks?

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"If I am not for myself, who will be for me? If I am only for myself, what am I? If not now when?" How often I have reflected on this three-lined quote attributed to the great sage Hillel. While it has been cited in the context of documentaries, speeches and in texts about spirituality and freedom, it is less considered for its context in the framework of healthcare.

The relationship between oneself and others has been an applied focus in psychotherapy. Therapists urge clients to attend to an awareness of potential blurring of boundaries, particularly when merging tendencies occur naturally in relationships. Whether this is due to overextending, or underextending, the relevance of caregivers in the treatments and day-to-day experiences of patients with chronic and/or terminal illnesses, it is a cornerstone of health care that is deserving of greater focus. Its contribution to disease progression and its influence in wellness practices cannot be overstated.

In developing clinical programs and research designs across several populations in our hospitals, two distinct elements have become apparent and have influenced not only the way we treat, but also the language we use to honor and distinguish all kinds of needs and treatment factors. In our designing a 9/11 Caring for the Caregiver project, we learned the subtleties and importance of identifying those with direct loss and those with secondary loss. Then, we also treated those who were treating those who had loss. We did this within a 'music therapeutic community' context.

Prior to constructing our stroke study, we conducted several focus groups pre-study and learned from stroke survivors that they wanted to be called "survivors" and not "victims." The survivors told us something else. There were clear that they disliked the term "caregivers" for their spouses and family members. They preferred the term "carers"-and readily distinguished "caregivers" and professional caregivers, who were hired-such as home health aids or nurses.

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We have therefore modified our languaging and include differentiation between personal and professional caregivers. And in the study we organized our focus group of the population we were studying, in the pre-design, we honored the patients' and personal caregivers' request to name family tenders, "careres." Interestingly, including professionals in research, where possible, particularly when there's inclusion of both how care is provided and also how patients perceive care do have influence on treatment outcomes.

There has been a notable increase in the study of personal caregivers and their role in treatment regimens within the past decade. In a recent systematic review, the Trajectory of Caregiver Burden and Risk Factors in Dementia Progression found a "limitation that none of the studies assessed caregiver resources, like personality traits, competence, or coping styles of the informal caregiver." (1) This would seem to be an important baseline for seeking to understand what can instill resilience in personal and professional caregivers, especially those who are at high risk for a reduction of quality of life in being charged to provide 'care' round the clock.

Maybe the more subtle debilitating effects of caring deeply come from being unaware of how detrimental caring can be in situations where we're seeking to be most helpful, particularly when there is sudden trauma and where crises call upon immediate and effective strategies from those closest to patients. A recent study assessing the stress among 100 parents of neonates showed that 60.8% parents experienced severe and extreme stress with no significant difference in overall stress between father and mother. Notably, the highest levels of stress experienced were in the "sight and sound subscale" and in the relationship with the baby and parental role." [2]

In communicating with two authors on their reflections of a recent study on preterm infants with severe brain injury, who demonstrated unstable physiological responses during maternal singing with music therapy, Prof. Shmuel Arnon and the lead music therapist on the study, Shulamit Epstein, based their design on previous work, that showed beneficial effects on preterm infants' physiological stability and reduced maternal stress during maternal singing combined with Kangaroo care [3]. Their previous study (4) along with other studies found that maternal and paternal singing could empower have the capacity to transfer connective intentions to their premature infants[5–8]. Previous studies have not included preterm infants with severe brain damage.

Arnon and Epstein hypothesized that maternal singing led by a certified music therapist, would have a positive effect, even in this at-risk group. (3) Unexpectedly, maternal singing during music therapy for these preterm infants with severe brain injury led to physiological and behavioral instability for both the preterm infants and their mothers, as documented by higher mean LF/HF ratio, heart rate, respiratory rate, infant behavioral state scores, and higher maternal anxiety score.

In raising some speculations on why preterm infants with severe brain damage reacted differently to the MT interventions, they show evidence that preterm infants with severe brain injury (IVH, PVL) suffer from sensory processing disorder or other neurological reactions due to illness [8]. Music processing ability, and possible prolonged morbidity and pain, resulting in changes in the organization of the nervous system, are areas they deduced might have affected their response toward music [9].

In discussing a caregiver perspective with the authors, and possible explanations for mothers' elevated anxiety and its potential effect on the babies, their realization that a parent's emotional state has a direct effect on their ability to synchronize and attune to her infant, was a recognizable possibility they felt might have led to the infant's increased arousal and thus his/her difficulties in resultant regulation [10].

They speculated that mothers could have been transmitting their anxiety to their infants while singing, resulting in unstable reaction among the preterm infants. However, they remain uncertain whether the infants' reactions were derived from mothers' reactions or vice versa.

As caregivers are apt to be in heightened states of anxiety particularly when their family member's level of severity and risk is at stake, providing music, even when guided by a music therapist may not be optimal. This is the brilliance of this study, which leads to more questions, namely, how best might we include personal caregivers in the provision of clinical interventions.

While the review of adult caregivers of people with Alzheimer's recognized a need for learning about caregiver resources, including their coping styles, studies of parents caring for neonates include a suggestion for incorporating opportunities for them to share, grieve, express their anxiety and/or process their emotions through psychotherapeutic support in a forum such as music therapy. In the majority of clinical cases and research studies we've read that suggest caregivers receive therapeutic intervention, a recommendation that could be surmized from the context of how such interventions could be best received might be that it would be in a context existing in a space separate from the patient-based therapy. The literature seems to point us in this direction.

The first issue in 2021 begins with an article from Kamile Geist presenting her *Randomized Pilot Study of Rhythm-Based Music with Movement Strategies on Stress and Interaction Behaviors of Infant Caregivers.* She studied the impact of caring for infants from 6 to 40 weeks on stress hormone levels monitored in caregiving parents as salivary cortisol levels and salivary cortisol/DHEA ratio values pre-post treatment (intervention with music and movement) as compared to a control (no intervention). Results indicate that participating in music experiences with their infants can impact the stress of caregivers. Further research seems promising while studying larger sample groups.

Mikaela Leandertz, Jussi Joukainen, Tuula Pesonen, Esa Ala-Ruona conducted a pilot case study looking into *Psychotherapeutically Oriented Vibroacoustic Therapy for Functional Neurological Disorder* described as disturbed communication between mind and body resulting in the experience of neurological symptoms incompatible with neurological or medical diagnoses. Both, diagnosis and treatment are complex. Their study utilized a psychotherapeutically oriented application of vibroacoustic therapy and active music therapy methods using a multimodal, interdisciplinary approach. Qualitative and quantitative outcome measures support clinical findings requesting again further controlled research with larger groups.

Quite another aspect of interrelationship of music, disability and science is highlighted in Tores Theorell´s article on *How a Child With a Disability Became a Nobel Prize Winner: Hugo Theorell (1903-1982) and his music.* In 1955 Hugo Theorell was awarded the Nobel Prize in Medicine. Disabled as a child by poliomyelitis he had used playing the violin to overcome his disability and become a world-famous scientist.

*Effects of music on behavior and the cardiovascular system in animals and human being*s are compared in a study conducted by Hans-Joachim Trappe looking into behavioral patterns in German Large White Pigs and cardiovascular parameters in human beings listening to so-called classical music from Bach (CL), heavy metal (HM) and to silence (S). Data about effects on humans were already published in an earlier version of this journal. In addition, Trappe could demonstrate that music from Bach lead to significantly more activity and attention of the pigs (e, g. playing ball) compared to HM or S.

Evaluating on a framework for impact of Council Group Singing Programs for Mental Health And Well-being, authors NaYoung Yang, Rosemary Jenkins, Elizabeth Dubois, Harumi Quezada-Yamamoto, Helen Ward, and Cornelia Junghans state that current scientific literature in music and medicine often lacks rigor and strength of quantitative research studies, while at the same time a lack of framework to organize data hampers access to research data. They propose a three-category framework to organize raw data tracing interactions of effects of participating in group music activities. Target groups ranging from two choirs in based in UK, to survivors of the so called 2017 Grenfell Fire disaster. Authors find the framework to be useful in these evaluations, suggesting future research to include mixed methods approaches.

Pipsa Tuominen, Jani Raitanen, Pauliina Husu, and Urho Kujala have conducted a pilot study on *The Effects of Music Mat Exercises on Device-measured Sedentary Time And Physical Activity Among 4–6-year-old Finnish Children And Their Parents*. Statistical analysis of data gained monitoring an eight-week exercise intervention through tri-axial hip-worn accelerometer, exercise diaries and questionnaires demonstrate no clear results were found. However, looking at the whole picture it may be concluded, that music mat exercises in home environment may promote physical activity or reduce sedentary behavior among those who are willing to use music mat regularly. We are looking forward to read further research on a topic of real importance with respect to forced home-stays for adults and children under Corona Pandemic.

An experimental case study about *Music Listening to Decrease Intensity of Agitated Behavior After Severe Acquired Brain Injury* is discussed by Lena Aadal, Søren Vester Hald, Ulla Johanna Setterberg, and Lars Ole Bonde. The study explores staff-administered listening to preferred music as an intervention to reduce agitated behavior in a sub-acute rehabilitation setting. Seven patients (6♂/1♀, aged 21-74 years) received 15 minutes of preferred music from a customized playlist created by a music therapist and hospital staff. Agitated Behavior Scale (ABS)-scores, blood pressure and heart rate measurement in combination with visual data suggest that listening to preferred music may reduce intensity of agitated behavior. Authors suggest further research with larger groups.

Our Editorial Team and Board are delighted to share with you, our readers, that our journal will be listed in SCOPUS in the coming weeks, which will increase the availability of these articles and the indexing of the journal. Thanks to you, our readership for participating in the growing evidence of music and medicine, in theory, research and in continued growth of practice. We look forward to a wonderful year.

Joanne and Ralph

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Full-Length Article

A Randomized Pilot Study of Rhythm-Based Music with Movement Strategies on Stress and Interaction Behaviors of Infant Caregivers

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Abstract

The purpose of this pilot study was to determine if caregiver stress hormones and positive interaction behaviors could change when participating in music with movement strategies while interacting with their infant. Participants recruited for the study were from volunteer caregiver/infant dyads. Infant inclusion criteria were ages 6 weeks to 10 months and caregivers were 18 years or older. Caregivers were excluded if they were currently taking oral prednisone or hydrocortisone or reported having or had an adrenal disease. Participants in the pilot included 13 caregiver/infant dyads, infants' ages ranged from 6 to 40 weeks and caregiver ages were 23 to 50 years. All caregivers were biological parents, 12 female and 1 male and each caregiver had no other children. Caregiver/infant dyads were then randomly assigned to a treatment music and movement intervention or control condition (no intervention). Each session lasted 30 minutes and pre-post session caregiver saliva was collected. Each session was video recorded to observe caregiver interactions with the infant. Results show significantly lower salivary cortisol levels and lower salivary cortisol/DHEA ratio values pre-post the treatment condition as compared to control. These findings suggest that participating in music experiences with their infants can impact stress of caregivers.

Keywords: ***caregiver, cortisol, movement, rhythm-based music, stress, infant*** multilingual abstract | **mmd.iammonline.com**

Introduction

Healthy interactions between a caregiver and an infant are critical to an infant's long-term cognitive, social, and emotional well-being [1-6]. Caregivers who nurture their babies and create secure attachment experiences through touching, moving, vocalizing, holding, and rocking, as examples, are providing experiences that help the baby to grow and thrive [3-5, 7]. Infants who do not experience the nurturing needed from a caregiver, may be insecurely attached, and tend to have difficulty with sensory and emotional regulation as well as difficulties dealing with emotional situations throughout their lives [1, 3, 5].

Music and Movement for Infants and Caregivers

The extant literature on the impact that primary caregivers, specifically maternal caregivers, who provide familiar and live music with rhythmic movement interactions with infants, supports the basic premise that infants need these interactions for brain development, attention, arousal, social cognition, physical growth, and emotional behavior competence [8-16]. Neuroscience entrainment research supports the use of rhythmic strategies when a caregiver is interacting with an infant [16-21]. For example, the benefits of caregiver singing in tempo with an infant's breath or other movement may benefit perception, calming, and attention for both the infant and caregiver [22-24].

Compelling recent evidence to the benefits of musical interactions for infants has centered around research for pre-term infants in the Neonatal Intensive Care Unit (NICU) and their families including impact on parent-infant interactions, and improvement of infant vital signs, feeding, and sleep [22, 25, 26]. NICU Music Therapy researchers are also documenting specific treatment strategies such as Creative Music Therapy [27], Music Therapy and trauma in the NICU [28], the impact of family-centered Music Therapy [29, 30], and the use of singing lullabies [12, 26, 27].

Movements have structure and phrasing and those such as sucking, kicking, moving arms and various developmental movements including rolling over, sitting alone, crawling, and ultimately balancing and walking can yield rhythmic patterns [31-34]. In a recent study, Tortora [7] provided a nonverbal analysis of attachment, indicating that the caregiver movements in relation to an infant's movements can influence the quality of the relationship [7].

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Caregiver and Infant Stress
It is well-established that if a person is repeatedly exposed to stressful situations, a variety of health problems may result, including high blood pressure, increased blood insulin levels, and weight gain [35]. Cortisol is a hormone secreted by the adrenal glands in response to stressful situations. Cortisol also impacts immune, cardiovascular, and cognitive functions [36]. Repeated or prolonged exposure to elevated cortisol can negatively impact our mental and physical health [37, 38]. Dehydroepiandrosterone (DHEA) can also be released in response to stressful circumstances but appears to work in opposition to cortisol [39]. Higher cortisol concentrations and cortisol/DHEA ratios are indicative of higher stress pathology while relatively lower cortisol/DHEA ratios indicative of resilience. There is also a growing body of evidence on how music positively impacts levels of cortisol and the cortisol/DHEA ratio for children [14, 40, 41].

Summary and Purpose of Study
The positive impact music and movement interactions can have for infant-caregiver relationships and their capacity to reduce stress is well documented [15, 34, 42-47]. Implementing rhythmic-based strategies and maternal infant-directed singing for reducing infant/caregiver stress and increasing positive social-emotional outcomes outside of the NICU is emerging [16, 24, 48, 49]. Measuring biological markers such as the stress hormones of caregivers and the potent use of music has the potential to inform future practice [51]. Therefore, the purpose of this study was to first see if observing, learning, and participating in a music and movement session facilitated by music and movement interventionists can provide a benefit of lower stress hormones among caregivers in caregiver-infant dyadic interactions. Second, are there more positive caregiver interaction-behaviors observed when participating in a music and movement lesson?

Materials and Methods

Study Design
This study was a pilot, single-blinded, randomized control trial to observe whether rhythm-based music and movement strategies demonstrated to an infant's caregiver, benefitted the caregiver's pre-post intervention stress measures as well as influenced the social interaction behaviors observed during the study sessions.

Participants, Inclusion and Exclusion Criteria
The study involved recruiting caregivers with an infant who was aged 6 weeks to 10 months to participate in two visits to the research site, one with caregiver alone and one with caregiver and infant. The caregiver was excluded if they reported currently taking oral prednisone or hydrocortisone and reported having or had an adrenal disease. Other inclusion criteria were that the caregiver must be age 18 years or older and both caregiver and infant meet health indicators (e.g. no fever, no symptoms of physical illness) at the time of the visits.

Recruitment and Randomization Procedures
Study recruitment information was distributed within the local community to solicit potential volunteers. Distribution was done through social media posts, emails to the University community, and flyers posted at libraries and other public venues. Caregivers interested in participation contacted the study team and completed a prescreen interview over the phone with a research team member to answer basic questions constituting the study inclusion and exclusion criteria. Those individuals passing the initial prescreening interview were scheduled for Visit 1.

Once Visit 1 was scheduled, the caregiver/infant dyad was randomly assigned by a research staff member to either the control or experimental condition using a randomization schedule as a concealment strategy. Participants were allocated to parallel groups at a 1:1 ratio. The caregiver/dyad was then assigned an identification number and a printed label with this number was placed on all consent forms, individual outcome measures, and in a secure data base. See Appendix A for randomization flow chart.

Caregiver-Only Visit 1
The Caregiver-Only Visit 1 was structured to answer any questions about the study and to gain informed consent. After gaining informed consent, a member of the research team, who was also a registered nurse, collected demographic information, collected baseline data including vital signs (i.e. height, weight, and pulse) as well as stress measures including perceived stress and a saliva drool sample. Visit 2 was scheduled within one week of Visit 1, around the same time of day for reliable comparison to baseline stress data.

Caregiver/Infant Visit 2
When the caregiver and infant arrived to the research site, they were asked to wait in a quiet lobby for approximately 15 minutes and then asked to complete the 10-item Perceived Stress Scale (PSS) [52]. They were then accompanied to a session room where a research nurse took the infant's temperature with a forehead thermometer to assess if the temperature was greater than 100.4° F per exclusion criteria. Caregivers had vital sign measurements taken, (blood pressure, heart rate, and temperature) and then a saliva sample collected. The vital signs of the caregiver and saliva were collected pre and post session. After submitting the first saliva sample, the caregiver was told which group to which they were assigned. Each session lasted approximately 30 minutes. While sessions were taking place, the participants were monitored by a member of the research team through a

web camera to ensure safety. Each session was also video/audio recorded for post study caregiver/infant interaction data analysis.

Measures and Data Analysis Procedures

Perceived Stress Scale

Data for self-report stress for the caregivers was measured by the 10-item Perceived Stress Scale (PSS) [52-54]. The PSS was completed by the caregiver at Visit 1 and Visit 2. The completed forms were collected by a member of the research team and scores were entered into a secure server by a member of the research team. The PSS measures the degree to which an individual perceives his/her life as uncontrollable, unpredictable, and overloading within the past month [52]. The PSS is closely linked with measures of psychological stress and self-reported health (depressive and physical symptomatology) [53]; it is also correlated with biological markers of stress and disease [55].

Summated scores were computed for Visit 1 and compared between both groups (intervention and control) for Visit 2. Reliability coefficients were assessed using Cronbach's alpha. Change scores of all the measured outcomes were computed as the difference between post-intervention/control and pre-intervention/control scores. Paired sampled t-tests (or their non-parametric equivalents) were used to determine the statistical significance of these scores across all study participants. All values of $p \leq .05$ constituted statistical significance at two-tails. The data for the PSS was analyzed by a qualified biostatistician.

Saliva Samples

The passive drool method was used to collect saliva samples approximately 20 minutes after arrival for Visit 1 (baseline) and Visit 2 (pre-intervention/control) and immediately after the 30-minute session (post-intervention/control). Samples were stored at -20°C and later centrifuged and assayed at the university site using standard enzyme-linked immunoassay procedures. All samples were assayed in duplicate and averaged. The assay had a sensitivity of < 0.007 μg/dL, and inter-assay coefficients of variation were less than 11.0% and intra-assay coefficients of variation were less than 7.0%.

Stress hormone measured outcomes (cortisol, DHEA, and cortisol/DHEA ratios) were collected for both visits baseline, pre-intervention/control and post-intervention/control. Hormone analyses were conducted for the female caregiver participants only (i.e., the one male caregiver was excluded from statistical analyses) because of well-established sex differences in salivary cortisol and DHEA [39]. The Wilcoxon Rank Sum test [56] was used to determine the statistical significance of these scores across all study participants or the experimental groups for two-matched periods of time. A two-sample non-parametric Mann Whitney test [57] was used to determine whether there were statistically significant differences between the two experimental groups with respect to these scores, All values of $p \leq .05$ constituted statistical significance at two-tails. The saliva samples were analyzed by a member of the research and student researchers who were trained in saliva sample analysis.

Caregiver Interaction Behaviors

Each session was video recorded. Video files were stored on a secure server and analyzed once all study sessions were completed. Adapted from Fahlberg's Parent Observation Checklist [58], four caregiver behaviors were observed for frequency of occurrence: Behavior 1, responds to the infant's vocalizations and/or other cues, Behavior 2, engages in face-to-face contact with the infant, Behavior 3, comforts the infant, and Behavior 4, initiates positive interactions with the infant. Frequency of behaviors observed for each observer was recorded. Total percentage of agreement across all four behaviors as well as individual behavior agreement was recorded.

Five independent observers, undergraduate seniors studying music therapy at a university in the United States, observed sessions in one sitting, requiring approximately 4 hours of time with scheduled breaks. Of the 13 total sessions, 2 session videos, a control and an intervention session, were not usable due to video equipment problems. Each observer was provided with a written observation protocol (see Appendix B) and observed 11 sessions (15 minutes each): 2 practice (control and intervention), 4 control and 5 intervention. Interobserver agreement was calculated for the 9 non-practice sessions across all behaviors and individual behaviors across all observers.

Session Room Description

The session room was an open space with two areas, an area for a nurse to take vitals of the caregiver and infant and collect the caregiver saliva sample. The other section of the room was decorated like a nursery and had a padded play floor, a rocker, a window with blinds, soft lighting, a changing table, developmentally appropriate toys and books, and a clock. There were two cameras in the room, one for audio/video recording and a webcam. The room did not have an observation window so the webcam was set up so a designated research team member could hear and see the control and intervention sessions from an adjacent room and be available immediately if the nurse, participants, or interventionists needed help.

Control Condition

Once entering the session room the infant and the caregiver had their temperature taken, then vital signs measured and salivary measurements were taken from the caregivers. The nurse then told the caregiver that they were assigned to the control condition. The nurse described what was available in the room (i.e. toys, rocker, changing pad, etc.), how long they would be there (indicating the clock on the wall), reminded the caregiver that they were being recorded for research purposes, where the cameras were located in the room and if they needed anything, a research team member was in the next room and could hear and see them via the webcam. There was no music playing in the background but there was ambient noise from the air conditioning and possible light noise. Caregivers were asked to stay in the room with their infant for 30 minutes and interact with them as they would normally do. The research nurse came in after the 30-minute session and took post session salivary and vital sign measurements of the caregiver.

Intervention Condition
Upon entering the session room the infant and the caregiver had their temperature taken, then vital signs measured and salivary measurements were taken from the caregivers. The nurse then told the caregiver that they were assigned to the intervention condition. The music and movement interventionists then entered the room, introduced themselves and explained the procedures for the session. The intervention condition, a 30-minute session, included 5-10 minutes of building rapport and asking the caregiver about the music experiences of the infant, how they interact musically, and any past music experiences of the caregiver. See Appendix C for the general outline of the session and lists of questions. The next 15-20 minutes of the session was delivering the music and movement intervention. The last 5-10 minutes of the session included reviewing key strategies that the caregiver observed and demonstrated and allowing time for the caregiver to ask questions. Once the 30 minutes was completed, the interventionists left the room and the research nurse came in the room to take the post session salivary and vital sign measurements of the caregiver.

Music and Movement Intervention
The overarching goal for the intervention was for the interventionists to demonstrate music and movement strategies that were accessible to the caregiver and receptive to the infant, allowing opportunities for the caregiver to interact with the infant musically, ask questions as needed, and receive feedback from the interventionists.

Intervention Process Framework
The music and movement interventionists used a 3-area process framework to guide the general flow of the eintervention session: Observation, Demonstration, and Assisting. At any point during the intervention, they were either observing the caregiver/infant music and movement behaviors, demonstrating music and movement-based strategies with the infant, or assisting caregiver demonstration and practice of a music and movement strategy with the infant.

Interventionists
The deliverer of the music was the music interventionist, also a music therapist with over 20 years of experience as a clinician working with infants, children, and families. The music interventionist took the lead with deciding on the musical content of the intervention and how it would be delivered. The caregiver was also encouraged to demonstrate any music and movement experiences they already use with their infant, practice the strategies observed and receive feedback from the interventionists.

The movement interventionist, a dance professor and trained and certified Laban [59] movement analyst, observed, offered advice related to positioning, touch, and movement patterns during the music and movement strategies. At times, the movement interventionist would step in and demonstrate how the caregiver could support developmental movement patterns and worked directly with the infant while the music interventionist provided musical structure for the experience through vocal rhythms and functional songs.

Intervention Delivery
The music and movement intervention delivery was live through voice, movement, or touch. The music interventionist chose music strategies in response to the infant's cues, the caregiver's questions, and the movement interventionists input. The music strategies were designed to be accessible and easily replicated by the caregiver. Decisions about aspects of the music were made in the moment and the intervention delivery also took the form of demonstration and education for the caregiver, explaining why certain music and movement strategies were beneficial for the infant's development. See Appendix D for list of pre-strategy decisions and list of music strategies.

Music Strategies.
The music strategies used included Infant-Directed Humming [15, 27], Infant-Directed Chanting/Singing [15, 16, 27, 48, 49], Rhythmic Touch [47], and Rhythmic Movement [60]. Infant-directed humming strategies included humming a melody of a familiar song, humming an improvised melody, and supporting movement patterns through humming. Infant-directed chanting/singing strategies included chanting or singing a song with familiar words, chanting functional concepts, and singing using a familiar melody but using functional concepts as words. Rhythmic touch strategies spanned from using rhythmic touch with no words or melody to pairing the touch with humming, chanting, or singing. Rhythmic movement strategies used aspects of humming, chanting, singing and touch with the primary goal of facilitating developmental movement patterns (i.e. pre-crawling, reaching, grasping)using techniques of Patterned Sensory Enhancement [60].

[Click for Video]

Results

Sample

The sample in this study consisted of 13 infant/caregiver dyads, randomly assigned to control and intervention groups (6 control and 7 intervention). Of the caregivers, 1 was male and 12 were female. There were 5 female infants and 8 male infants; the infants ages ranged from 6 to 40 weeks and the age ranges of the caregivers were 23 to 50 years. All caregivers were biological parents and the infant was their first child. Other demographic characteristics of the study participants are delineated in Table 1.

As shown in Table 1, the study involved 13 caregiver/infant dyads with 7 in the intervention arm and 6 in the control arm. Other demographic characteristics of the study participants are delineated in Table 1 also.

Table 1. *Characteristics of study subjects (caregiver/infant dyad N = 13)*

Characteristics*	Control (*N*=6)	Intervention (*N*=7)	P-value
Caregiver gender, *N* (%)			0.34
Female	6 (100)	6 (85.7)	
Male	0 (0)	1 (14.3)	
Infant gender, *N* (%)			0.14
Female	1 (16.7)	4 (57.1)	
Male	5 (83.3)	3 (42.9)	
Ethnicity of caregiver, *N* (%)			0.53
White/Caucasian	3 (50)	2 (28.6)	
Hispanic	0 (0)	1 (14.3)	
Not Reported	3 (50)	4 (57.1)	
Marital status of caregiver, *N*(%)			0.26
Married	5 (83.3)	7 (100)	
Chose not to answer	1 (16.7)	0 (0)	
[a]Caregiver age in years, *M* (*SD*), [range]	33.0 (9.12), [23- 50]	30.29 (4.64), [27- 40]	0.50
[b]Infant age in months, *M* (*SD*), [range]	3.5 (2.07), [1-7]	5.6 (1.90), [3-8]	0.09
[c]Perceived stress (visit 1), *M* (*SD*), [range]	17.17 (1.95), [15 20]	17.5 (4.51), [11 24]	0.87

**N* = number of subjects, *M* = mean, and *SD* = standard deviation, [a]95% CI = [-5.91 11.34]; [b]95% CI = [-4.50 0.36]; and [c]95% CI = [-4.79 4.13]

No statistically significant differences were observed among the baseline characteristics between the intervention and the control groups. All the p-values in Table 1 were greater than or equal to the level of significance (alpha) = 0.05.

Stress Measures

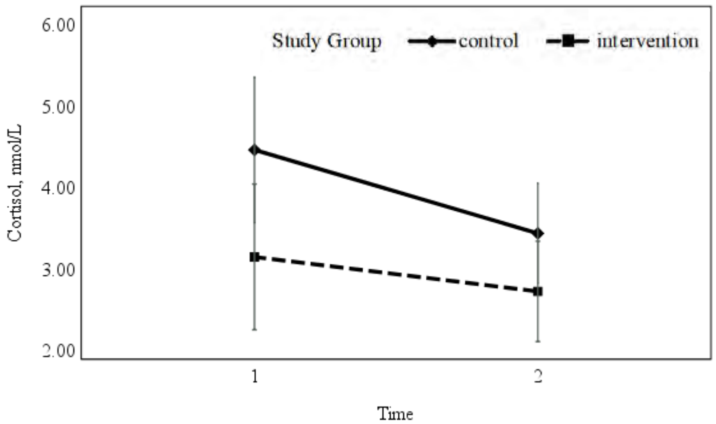
There was no statistically significant difference in the Visit 1 perceived stress (PSS), see Table 1, between the control and intervention groups, p = 0.87. In Table 2, unadjusted for Visit 1 hormone levels, the intervention group had shown on average higher cortisol values than the control at baseline (Visit 1) and the pre- and post-intervention periods. However, while the measured cortisol levels systematically decreased over baseline for the intervention group (Visit 1 through Visit 3), those for the control group varied in a non-systematic manner (increased from Visit 1 at Visit 2 but decreased at Visit 3) . The systematic decrease in the average cortisol levels in the intervention group was statistically significant ($\chi^2(2) = 8.857$, $p = 0.012$).

Table 2. *Mean, standard deviation, and range for values of the stress hormones*

Measure	Visit 1	Visit 2 (pre-condition)	Visit 2 (post-condition)
Cortisol, nmol/l			
Control	3.23 (0.85), [2.1 4.3]	3.65 (1.32), [1.7 5.6]	2.85 (0.76), [2.2 4.1]
Intervention	5.22 (1.66), [3.4 8.2]	4.78 (2.67), [2.7 9.8]	3.57 (1.37), [2.0 5.4]
DHEA, nmol/l			
Control	0.32 (0.05) [0.2 0.4]	0.37 (0.09) [0.3 0.5]	0.31 (0.10) [0.1 0.4]
Intervention	0.48 (0.18) [0.3 0.8]	0.37 (0.08) [0.2 0.4]	0.34 (0.14) [0.2 0.5]
Cortisol/DHEA, nmol/l			
Control	10.77 (4.12) [6.0 15.6]	10.55 (5.96) [5.1 21.6]	11.59 (9.28) [5.8 29.6]
Intervention	12.21 (7.76) [4.5 26.7]	11.38 (5.83) [6.2 22.1]	10.74 (4.89) [5.6 16.7]

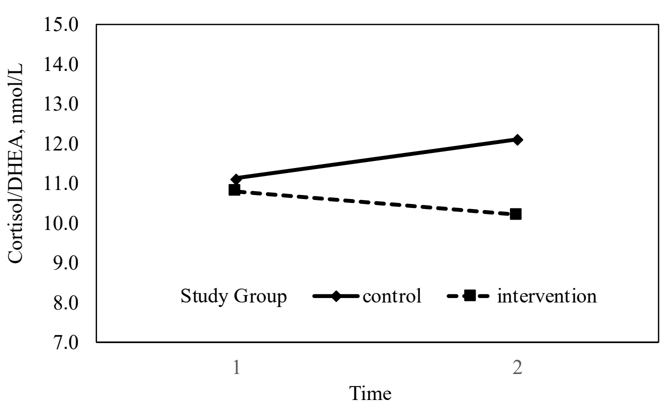
The intervention group showed significantly lower cortisol levels at Visit 2, across both pre- and post-intervention/control time points, $F(1,9) = 5.07$, $p = .05$, controlling for Visit 1 hormone levels (see Figure 1). There was no difference in salivary cortisol levels over time between the two groups. The points on the confidence interval (CI) bars shown on Figure 1 represent the estimated mean cortisol values at each time point for each condition. The 95% CI bars indicate that the researchers are 95% confident that the population mean cortisol values fall within the ranges of these intervals.

Figure 1. *Salivary cortisol by study condition at Visit 2. Time 1 = Pre-intervention/control; Time 2 = Post-intervention/control; Error bars represent 95% confidence intervals.*



There were no group or time differences in salivary DHEA alone. Also, there were no significant time or group difference for cortisol/DHEA ratio averaged across both pre and post time points. The resulting pattern (see Figure 2) suggests that cortisol/DHEA ratio values were higher after the control condition and lower after the intervention condition.

Figure 2. *Salivary Cortisol/DHEA ratios by study condition at Visit 2. Time 1 = Pre-intervention/control; Time 2 = Post-intervention/ control*



Caregiver Positive Interactions

Once beginning the study, without watching any video, the researchers realized that the design of collecting parent interaction data was potentially flawed because the control and intervention condition environments did not inherently provide the same amount of time and opportunity for the caregiver to interact with the infant. A decision was made to continue video recording the sessions and analyze the sessions using Fahlberg's [58] observation protocol as planned (See Appendix B). In consultation with the biostatistician and because the outcome frequency of behaviors were not comparable, a comparison of frequency of behavior means analysis was not conducted. Interobserver agreement over all behaviors and observers for the control sessions was . 3 and for the intervention group .25.

Discussion

Impact

The authors agree that the most impactful result from this pilot, even with the small sample, was the significant decrease in caregiver cortisol pre-post intervention when compared to the control. Though there is limited research on infant caregiver cortisol levels after using music, these results are consistent with infants' cortisol decreases after having been exposed to musical experiences in the NICU [40, 41]. The cortisol/DHEA ratio trended lower, on average, post-intervention and higher, on average, post-control. This trend is meaningful and should be explored further in future research since DHEA is associated with counteracting the effects of cortisol [39].

Limitations

One limitation of the study is that of the small sample. Although it is recognized that this was a pilot, the authors wish to expand the study to a larger sample to gain a more reliable observation on the impact of the intervention. Another limitation was that the parent interaction observational design of the study was flawed because the control and intervention conditions did not match with the amount of time the caregiver was given the opportunity to interact with the infant. A future study could address these design flaws in two ways: 1) Add a pre and post session with just the caregiver and infant interacting with each other or 2) Provide a control condition where the caregiver is presented with a 30-minute training without music on how to have positive interactions with their infant. Future research should include a much more reliable training of observers and not let the observations continue until meeting an acceptable .08 IOA. It is suggested when the study expands, to build in feasibility measures to ensure that the delivery of the intervention is consistent.

Conclusions

The findings of this pilot suggest that music and movement interventions are promising for lowering stress hormones among infant caregivers and are consistent with past findings of social emotional benefits of using music and movement interventions to promote long lasting and health caregiver-infant relationships [1-16]. These interactions in and of themselves could transform the caregiver-infant dyad social-emotional relationship and perhaps prevent negative long-term effects related to lack of prolonged bonding and attaching experiences.

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Kamile Geist is a Professor of Music Therapy, board-certified music therapist, clinical and research focus in early intervention, who holds a PhD in Curriculum and Instruction with a cognate in Educational Research Methods from Ohio University, an MA in Music Therapy from Texas Woman's

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Lee Ann Williams is a Certified Clinical Research Professional (CCRP) through the Society for Clinical Research Associates, who holds an M.Ed. in Educational Administration from Ohio University and a B.A. in Psychology from Marietta College.

Brianna Tuttle is in the process of attaining a Master of Music degree in Music Therapy from Ohio University. She holds a Bachelor of Music in Piano Pedagogy with a minor in Psychology from Capital University in Columbus, OH.

Appendix A

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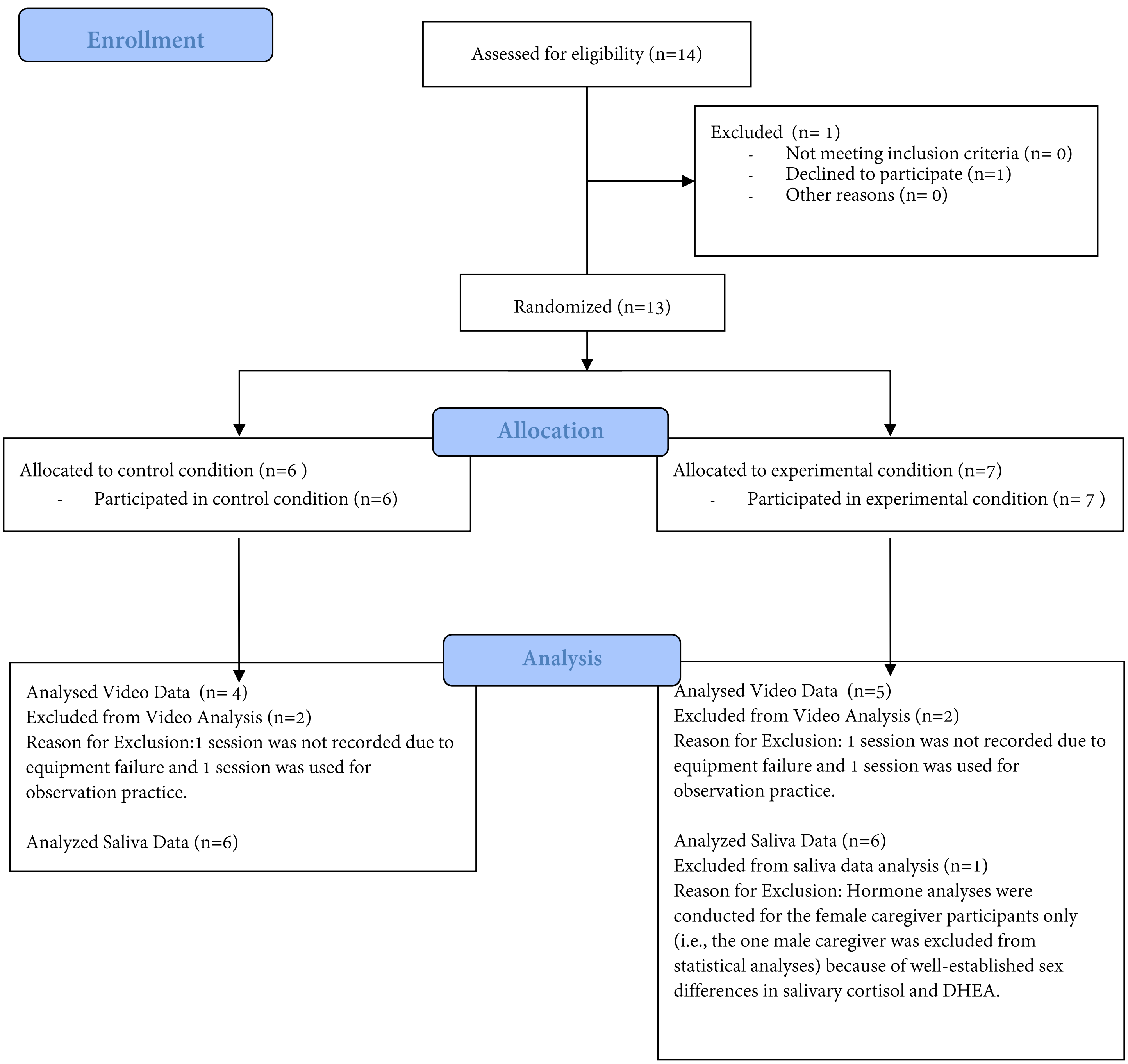
ADAPTED from the CONSORT 2010 Flow Diagram
Infant/Caregiver RCT PILOT



Appendix B

Video Observation Directions and Data Collection

Note from authors: EACH OBSERVER WAS GIVEN A DATA COLLECTION SHEET WITH DIRECTIONS FOR EACH SESSION OBSERVATION

Directions for Observing Practice Sessions or Sessions
Materials Needed: Directions and Data Collection Form, Timer

1. Enter your secure user name and password to access the desk top on the computer.
2. Open the file folder labeled ICMM video files.
3. Open the file folder labeled ICMM Practice Sessions (or ICMM Sessions)
4. Watch each practice video for 15 minutes. (set a timer)
5. For each video, tally how many times you see the following behaviors using the following data collection form.
6. During the practice only, contact the professors (CONTACT INFORMATION WAS LISTED HERE) if you have questions or need clarification on the process or behaviors. Be sure to get any clarity you need regarding the observations before you move to the non-practice session observations.

   Observer: PUT YOUR NAME HERE
   Date of Observation:
   Time of Observation:
   Place of Observation: NAME of Unit at University
   Video observed: PUT TITLE OF FILE HERE
   Type of Observation (circle one): Practice Session or Session
   Type of Session (circle one): Control Intervention

Behavior	**Number of Times observed**
Parent/caregiver responds to the infant's vocalizations and/or other cues	
Parent/caregiver engages in face-to-face contact with infant	
Parent/caregiver comforts the infant	
Parent/caregiver initiates positive interactions with the infant	

7. Once you have completed your observation, put this form in the folder marked "ICMM Study Observation Forms".
8. Start next video observation.

Appendix C

General Outline of Experimental Session

Rapport and Informal Assessment – Protocol (1st 5 minutes of experimental session)

1) Introductions
2) Questions about how music is used when interacting with the infant. Sometimes, the baby was ready for interaction so the questions to the caregiver came up during the session and helped guide which experiences were most relevant to the caregiver.

   What type of music (if any) do you play at home?
   Do you play music for your baby?
   Do you sing with your baby? If yes, what songs to you sing?
   Are there certain times of the day or during certain routines when you use music to interact with your baby?
   Do you ever sing or play for you baby any of your favorite songs?
   Do you have a musical background?

Intervention – 15-20 minutes of session

Closing – 5-10 minutes of session

1) What did we do today that you think you might use when you are at home with your baby?
2) Based on what we did today, we recommend…
3) What questions do have of us?

Appendix D

Music Interventionists' Pre-Strategy Decisions

Beginning Interventionist: Participant Ratio

1:1 with infant (caregiver and other interventionist observe)
1:2 with infant and caregiver (other interventionist observes)
2:1 with infant (caregiver observes)
2:2 with infant and caregiver (allowing one of the interventionists to lead the strategy and the other supports through providing music or movement structure through touch or vocalizations)

Beginning Delivery Environment

On the floor (infant on back or on belly)
Holding the infant while sitting on the floor
Holding the infant while standing or walking in the room
Holding the infant while he/she faces a caregiver or an interventionist.
Rocking the infant.
Infant in car seat while caregiver or interventionist faces them on their level.

Music Medium

Voice
Movement
Touch
A Combination (voice, movement, touch)

Dynamics

Start f, mf, p and stay the same
Start f, mf, p and gradually get softer and/or louder

Tempo

Start at medium walking tempo and keep the same tempo
Start at a fast, medium, and slower tempo and stay the same.
Start at a fast, medium, and slower tempo and change the tempo.

Meter

Duple or Triple

Music and Movement Strategies
Infant-Directed Humming (IDH)
Melody of a familiar song.
Improvised Melody
IDH - Patterned Sensory Enhancement
Infant-Directed Singing (IDS)
Melody and words of familiar songs
Melody of familiar songs but functional words to the songs.
IDS - Patterned Sensory Enhancement
Rhythmic Touch (RT)
Rhythmic Touch (no words)
Rhythmic Touch (chanting)
Rhythmic Touch (humming)
Rhythmic Touch (singing)
RT - Patterned Sensory Enhancement
Rhythmic Movement (RM)
Rhythmic Movement (no words)
Rhythmic Movement (chanting)
Rhythmic Movement (humming)
Rhythmic Movement (singing)
RM - Patterned Sensory Enhancement

Full-Length Article

Psychotherapeutically Oriented Vibroacoustic Therapy for Functional Neurological Disorder: *A pilot study*

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Abstract

Functional Neurological Disorder (FND) affects a significant number of people worldwide. Previously referred to as conversion disorder, FND is a disorder of the communication between mind and body resulting in the experience of neurological symptoms incompatible with neurological or medical diagnoses. FND patients account for a notable portion of neurologists' patients, and yet these patients are still considered some of the most difficult to diagnose and treat. This pilot case study utilized a psychotherapeutically oriented approach to vibroacoustic therapy and active music therapy methods in the therapy process of a patient diagnosed with FND. The treatment protocol used in this study highlights an interdisciplinary, multimodal, and diverse approach to referral and treatment for FND patients. Review of the qualitative data together with the quantitative outcomes of the study provided a comprehensive conceptualization of this case. Valuable perspectives were gained from this approach, and the clinical findings were well supported by the quantitative outcome measures.

Keywords: ***Functional Neurological Disorder, Dissociation, Vibroacoustic Therapy, Music Therapy, Interdisciplinary***

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Introduction

The relationship between mind and body has long been investigated. How the mind influences the body and vice versa is a multifaceted subject within the worlds of medicine, psychology, and health and wellbeing. These fields overlap in the study of Functional Neurological Disorder (FND). People who suffer from FND experience functional symptoms that may be physical or minor pathological perceptions [1,2], and include paralysis, speech problems, non-epileptic seizures, and chronic pain [1,3,4,5]. In addition to the range of symptoms FND patients may experience, there are multiple comorbidities commonly associated with the diagnosis, including mood disorders, generalized anxiety disorder, phobias, obsessive compulsive disorder, post-traumatic stress disorder, dissociative disorder, schizophrenia, and personality disorder [3, 4, 6]. FND is one of the most common conditions that neurologists encounter in practice, and yet these patients are considered some of the most difficult to help [1]. Treatment depends on the experience of symptoms, and can commonly include cognitive behavioural therapy (CBT), psychotherapy, and/or physiotherapy [7]. Pharmacotherapy may be a suitable treatment for comorbid depression, anxiety, and/or pain [7]. Depending on the symptoms, referrals are often done in parallel, with FND patients seeing multiple specialists and therapists concurrently.

FND is often referred to as a mind-body disorder because of the common relationship between psychological conflict and the experience of functional symptoms. The researcher questioned what the outcome would be if a treatment protocol was implemented that could treat the mind and body simultaneously, rather than in separate therapies. Would a mind-body treatment such as vibroacoustic therapy (VAT) be a suitable treatment option for a mind-body disorder such as FND?

VAT consists of flexible, diverse clinical applications that utilize sinusoidal, low-frequency sound waves (between 30-120 Hz) combined with music and therapeutic interaction [8, 9]. The efficacy of VAT as a form of treatment for chronic pain, stress related symptoms, muscle spasticity, motor impairments, and cognitive concerns has been established with a growing body of evidence [8-13].

The aim of this study was to develop a multimodal treatment protocol for FND patients using VAT and active music therapy rooted in psychotherapeutic orientation. The protocol aimed to simultaneously address physical and psychological needs of the patient while maintaining flexibility for the patient's possible range of symptoms and individualization of the interventions, aims, and objectives, as

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a foundational aspect of music therapy. In order to propose a treatment protocol suited to FND patients, it was necessary to first conduct a pilot study to also see the broader picture of the patient's functioning, the functioning of symptoms, interactions with symptoms, coping mechanisms, and potentials.

Methods

The study took place at the Music Therapy Clinic for Research and Training at the University of Jyväskylä. The music therapy clinic is well equipped with a variety of instruments and electronic midi-instruments. For vibroacoustic therapy, the clinic is also equipped with the Next Wave Physioacoustic chair.

Permission to study was granted from the Central Finland Healthcare District prior to receiving the patient referral. The referred patient provided consent for the study by reading and signing an informed consent document. The referral for the patient was received from a clinical neurologist of the neurological rehabilitation and acute ward of the Central Hospital. The music therapist in this case is an accredited and board-certified music therapist who completed her undergraduate education and clinical training in Canada, prior to pursuing graduate studies in Finland. The music therapist received regular clinical supervision throughout the therapeutic process.

The data collected for the study were mixed methods, however the aim of the study was not to report these data according to specific mixed methodology analysis measures. Because of the true pilot nature of this single case study – piloting a treatment intervention, as well as piloting music therapy work with this clinical population in general – it was crucial that the study did not focus on effectiveness necessarily, but a better understanding of the characteristics and qualities of the individual patient, and the quality of their interactions with their FND diagnosis in order to inform future studies. There was not enough background knowledge to justify a large-scale effectiveness study, therefore the current study was conducted with the aim of investigating the potential of this clinical approach, to inform future studies. As is common in flexible designs, the consequences of the study are only known after the events are analyzed [14]. "Case studies are often the study of process, so that we can retrospectively discover the hypothesis and the consequences as an emerging and completed story" [14, p.175-176]. Thus, the data collected in this study were intended to contribute to a more complete, whole picture of the individual case.

Qualitative material from the study included session notes (clinical observations), clinical assessment, final clinical report, and the recorded video and audio of sessions. Video recordings were reviewed inductively in order to contribute to the therapist's clinical notes as a method of session review to check and verify clinical observations, as well as to bring any additional perspectives to the clinical observations. A thematic analysis of the clinical notes was conducted to determine the turning points of the therapeutic process.

The quantitative measures for this study were selected based on the assessment information in the referral, as well as common symptoms/comorbidities of the clinical population. The Hospital Anxiety Depression Scale (HADS) uses 14 items to assess the presence and frequency of symptoms of anxiety and depression [15]. The anxiety subscale was used in this case (HADS-A), which contains 7 items, each coded from 0-3. The coded scores are then added to form the final score, which can range from 0-21, depending on presence and severity of symptoms (higher score indicates frequent presence/higher severity of symptoms). A review of the properties of HADS concluded its good internal consistency and concurrent validity in its use with a variety of clinical populations [16]. The Montgomery Åsberg Depression Rating Scale (MADRS) is a 10-item scale completed by the assessor following a semi-unstructured interview [17]. Each item is scored by the assessor from 0-6, with a higher score indicating higher levels of depression. MADRS has high interrater reliability and strong correlation to other standard depression scales [18]. The Dissociative Experiences Scale (DES) is a self-report questionnaire that evaluates the frequency of dissociative occurrences in everyday life [19,20] and has been shown to have good internal reliability, excellent convergent validity with similar questionnaires and good predictive validity particularly in areas of dissociative disorders and traumatic experiences. [19,21]. It consists of 28 items, and subjects are asked to indicate the percentage of time (in the past week) they had experienced the described phenomena (in increments of 10%). A total mean score, and mean scores of 3 subcategories can be calculated. This tool is not a diagnostic instrument, but a screening method, in which a higher score indicates more frequent occurrences of dissociative behaviour. The RAND-36 is a widely used health-related quality of life measure that provides 8 index scores under two dimensions of physical and mental health [22]. The RAND-36 has been supported as a reliable and valid measure of health-related quality of life in the finnish general population, and these results were consistent with other international studies of the RAND-36 [23]. Higher index scores for the RAND-36 indicate a better health-related quality of life. Visual Analog Scales (VAS) were used to record the patient's subjective pre- and post-vibroacoustic treatment outcomes.

Therapeutic Approaches and Clinical Methods

The efficacy of VAT as a form of treatment for a range of concerns and diagnoses has been established with a growing body of evidence [8-13]. It has also been suggested that VAT, especially when psychotherapeutically oriented, may be a beneficial treatment for psychosomatic symptom relief [9], though currently only anecdotal evidence exists.

Bruscia [24], states the core foundation of music psychotherapy as being the therapeutic relationship. Though the therapeutic interventions themselves may utilize different resources, verbal psychotherapy and psychotherapeutically oriented music therapy are unique from other therapies because it is the therapeutic relationship that paves the way for the work toward clinical aims. Sheiby [25] argues that the therapeutic relationship built in music psychotherapy is a more mutual relationship than that which exists in traditional verbal psychotherapy. The main difference between the two is the music experience, which exists alongside the verbal interaction in psychotherapeutically oriented music therapy [24]. The use of music is adaptable to the therapeutic situation, goals, and specific client needs. Work can be completed entirely with and through music, or it can be done primarily through verbal exchange with music as a facilitator [24,26].

Clinical improvisation was used in this case to process material on a non-verbal level. Defined by Wigram [27], clinical improvisation is, "the use of musical improvisation in an environment of trust and support established to meet the needs of clients" (p.37). During phase 2 of the therapeutic process, clinical improvisations were recorded and edited for layering tracks and/or clarity using Garageband. Upon the therapy's closure, the tracks were compiled in a playlist to share with the patient.

Sessions shared a consistent order of interventions used; Vibroacoustic treatment with music listening, verbal reflective processing, clinical improvisation (referential), closing with brief verbal reflection.

Therapeutic Process and Course of the Study

In order to explore the implications of the use of a psychotherapeutic approach to VAT with FND patients, a mixed-methods single case study design was implemented. This pilot case study consisted of hour-long sessions, twice a week, for 10 weeks. Phase one of treatment comprised of seven sessions, followed by a one-month washout period to monitor any carryover effect. Beginning phase two with the second set of standardised inventories also determined a new baseline for the second phase of therapy. Phase two consisted of the remaining thirteen sessions and was followed once more by a one-month washout period to once more monitor any carryover effect. The questionnaires and interview were administered immediately prior to the music therapy session and were conducted by the supervisor in the patient's native language. The final clinical report was based on the therapist's clinical notes and observations, and addressed the clinical aims established in the original clinical assessment, as well as any additional observed findings from the therapeutic process as a whole. A complete schedule of the case study together with the qualitative and quantitative outcome measures can be seen in Table 1.

Table 1: *Case study schedule with qualitative and quantitative outcome measures.*

	PHASE ONE		
Sessions 1-4: Assessment	Assessment: Music Psychotherapy Assessment [28]	VAS	HADS MADRS DES RAND-36
Sessions 5-7: Working Period	Clinical notes, video/audio review	VAS	
	ONE MONTH WASHOUT		
	PHASE TWO		
Sessions 8-16: Working Period	Clinical notes, video/audio review	VAS	HADS MADRS DES RAND-36
Sessions 17-20: Closure	Final clinical report	VAS	HADS MADRS DES RAND-36
	ONE MONTH WASHOUT		
			HADS MADRS DES RAND-36

The structure of each session remained consistent for the extent of the therapeutic process. A brief check-in was followed by a 20-minute relaxation VAT program with client-preferred music played in the background over the room's speakers. A relaxing program was selected using the accompanying computer software for the Next Wave Physioacoustic Chair. A program is defined as relaxing due to its slow pulsation (slower amplitude change), with varying intensities centering around 40 Hz. This frequency selection followed the principle for common practice in VAT, where it has been suggested that sound vibrations of 40 Hz would be a starting point for basic research [29] Client preferred music for relaxation for this case primarily included instrumental music from the classical and romantic eras. Some examples of this music are outlined below, in Table 2. The music was selected not only to be suited to the client's preferences, but also to lend to the relaxing program itself. Thus, the music therapist selected music with relatively slow tempi, no drastic or rapid changes in tempo or dynamic, instruments with a soft timbre, and music that was relatively safe and predictable in nature. Any thoughts, images, memories, bodily sensations, or emotions that occurred during the treatment were processed verbally with the therapist following the treatment, and then material was processed on a deeper level using music improvisation. Each session ended with a brief period of closure, to overview the themes covered and reorient the patient (if needed) to the present moment. Descriptions of some of these improvisations are included within the case vignette.

Table 2: *Examples of pre-recorded music played during VAT (client-preferred)*

Nocturne in B-Flat Minor, Op. 9, No. 1	Frédéric Chopin
Nocturne in E-Flat major, Op. 9, No. 2	Frédéric Chopin
Nocturne in F Minor, Op. 55, No. 1	Frédéric Chopin
Cello Concerto No. 1 in C: II. Adagio-Cadenza	Joseph Haydn
Volshebnoye Ozero (The Enchanted Lake) Op. 62	Anatol Liadov
Serenade for Strings in E-major op. 22 B. 52: IV. Larghetto	Antonín Dvorák
Symphony No. 2 "London": II. Lento	Vaughan Williams
The Planets, Op. 32: II. Venus, the Bringer of Peace	Gustav Holst
Capriol Suite: V. Pied-en-L'air	Peter Warlock

Results

Qualitative findings are presented within a case vignette. Specific therapeutic turning points were identified by the clinician following a thematic analysis of clinical notes. These points were recognized as having changed the progression of therapy in some way and/or contained thematic/interventional material that was utilized at multiple points throughout the therapeutic process. These points are presented within the case vignette in order to provide a deeper view of the turning points within an accurate timeline as well as to draw connections between the turning points and the case as a whole. The turning points, described below in italics, are based on direct excerpts from the therapist's clinical notes, allowing an in-depth narrative of the turning points.

Case Vignette

The patient, who we will refer to as Mariana for this case study, is a female in her mid-twenties. Mariana was taken to the emergency department via ambulance presenting with loss of consciousness, full-body paralysis, and seizure-like activity. Prior to this, Mariana had visited the hospital twice with similar symptoms. She was assessed at the hospital by a neurologist and a psychiatrist, eventually resulting in the diagnosis of FND. The prescribed treatment was cognitive psychotherapy, and at the time of the study, Mariana had been attending these sessions for two years. The referral noted comorbid diagnoses of anxiety and depression, and noted dissociative symptoms including dissociative amnesia and dissociative seizures. Prior to therapy, the researcher and supervisor consulted with the neurologist regarding the referral in order to better define assessment elements and establish a treatment plan. The researcher and supervisor also consulted with the patient prior to the start of therapy, to review consent forms and answer any questions about the study. First impressions of the patient during this initial consultation were that she seemed to be fairly well functioning and was able to describe some of her experiences with her FND diagnosis, symptoms, and her current treatments.

The music therapist's clinical assessment resulted in four aims:

1. To reduce the client's subjective levels of anxiety
2. To develop effective coping tools and strategies for situations in which anxiety levels are high, and/or the client begins to lose her sense of control
3. To increase the client's level of comfort in existing and new relationships
4. To increase the client's level of musical independence and confidence in self-expression, while relating these factors to the client's everyday life.

During the initial sessions, Mariana was hesitant and noticeably anxious, especially in any active music-making (clinical improvisation) scenarios with the music therapist. Despite her anxiety, and even the experience of a freeze response (see "Turning Point 1"), Mariana had expressed repeated interest to try improvisation as a new means of expression which is why it continued to be used as a therapeutic intervention throughout the process.

Turning Point 1: The Freeze

During the first session, the patient experienced a freeze response when invited to play the djembe. Though the client *expressed verbally that she was willing to participate in an improvisation with the music therapist, Mariana physically froze when the task began. She had closed body language – arms crossed across the chest with hands grasping her shoulders, legs crossed, slouched posture with shoulders forward, and no eye contact with the therapist. With encouragement from the therapist, Mariana was able to touch the instrument and make slight rubbing/tapping motions on the drum for short periods of time. The therapist considered the possibility of the instrument itself causing the freeze, especially considering that the patient would only tap or rub the drum, and not go through the typical motion of hitting the drum.*

Patient: "This is very difficult. The sound is… I don't know why but it's very… [gestures with arms]"

Therapist: "You can feel it in your body?"

Patient: "Yeah… I don't want to."

It was also during the initial phase of therapy that Mariana experienced dissociative symptoms during the vibroacoustic treatment. The referral had indicated that the patient experienced dissociative amnesia of her childhood. During one of the initial vibroacoustic treatments, the background music prompted imagery of a new memory for Mariana. She explained that she was around the age of 10 during the memory and stated that this was probably her earliest memory.

Mariana also experienced dissociative symptoms of depersonalization and derealization during the VAT portions of sessions. She described the sensation as feeling as though everything in the room, including the therapist, was very close to her but simultaneously far away. She heard the music as if it were playing in the next room, and described an out-of-body experience, viewing the clinic space from above. Mariana explained that she had experienced these symptoms leading up to her most recent paralysis attack. These sensations were processed with the therapist, and as the therapeutic relationship developed, Mariana explained that while these sensations had once induced feelings of anxiety and panic, experiencing the dissociative symptoms while in the presence of safety with the therapist allowed her to explore the sensation without panic.

The experience of these symptoms during the treatment not only emphasize the work with imagery and associated emotional content in this case, but the importance of fully processing this content on multiple levels in a safe environment. Mariana also found a sense of safety with an image that she had previously developed with her psychotherapist, that she referred to as her Safe Space.

Turning Point 2: Safe Space

Towards the end of the assessment period, the client experienced imagery of her safe space during the vibroacoustic treatment. The safe space was well-established – the patient was able to describe the sounds, smells, and how it changed through the seasons.

Because the safe space was so well established, the therapist and the patient improvised a soundtrack to accompany the image with the patient playing the ocean drum and the therapist playing the piano. The first time that this soundtrack was improvised marked the first time that the patient showed little to no hesitation and played with more focus and intention than previously demonstrated. The key, progression, and thematic material for the soundtrack of the safe space was used during other points of the therapeutic process in future improvisations, as a way to ground and reorient the patient if needed. The use of the ocean drum by the patient in future sessions often represented themes of calm, peace, and safety.

Prior to the improvisation, Mariana had described her safe space in detail, which prompted the music therapist to introduce her to the ocean drum, and encourage her to think of her safe space, and the waves (both big and small). While Mariana played, the music therapist improvised on the piano. The accompanying improvisation consisted of a rocking motion in the bass that followed the tempo provided by the ocean drum with a simple, slow melody in the mid-range of the piano. The therapist played in E flat major, using a I-IV-vi-IV-I progression.

Mariana gradually became more comfortable with referential improvisations, and this material became increasingly complex and symbolic. During the beginning of the second half of the therapeutic process, Mariana initiated a discussion about the personal aim she had for herself of emotional independence, which sparked a project that would continue for the remainder of therapy sessions.

Turning Point 3: The Hallway

Mariana formed the image of a hallway during her vibroacoustic treatment in session eleven, and the image continued to develop and transform as sessions progressed. The hallway represented the path that she was on towards independence and was used as referential material for future improvisations. As Mariana added more layers to her image, she was able to gain confidence in not only describing the sounds that she desired in the improvisation, but also in directing the improvisation itself. These improvisations were recorded for the remainder of sessions to fulfill a project that Mariana proposed, to depict her journey through the hallway. Recordings included an improvisation referencing her most recent paralysis attack, looking at new obstacles with a newfound "childlike sense of curiosity", and concluding with "Intensity", which Mariana described as, "joy, it's adrenaline, it's effort, it's the impulse to work, to do something that you're passionate about".

The client was able to select instruments and describe sounds to represent different aspects of her imagery. On a musical level, the therapist's notes indicate the client's great attention to detail and improved sense of confidence when conducting the improvisation, "Childlike Curiosity", for example:

Musically, the sound of 'the obstacle' has now changed from the bass hand drum, to notes on the xylophone. The sound of steps needed to be slow, calm, and have feet firmly in the ground. She chose a low tone bar (tone A), to represent these footsteps … Music therapist and client played the keyboards for the background music, which started with a slow, climbing motif to depict the increase of light entering the hallway. The client then introduced a single-line melody for the childlike curiosity … The obstacles/footsteps were recorded separately after the piano theme. The client played mostly ascending short, slow, melodies on the xylophone, representing the gradual growing obstacles, and nodded to the music therapist when it was time to take a step (play the tone bar).

The separately recorded parts of the image were edited together later, as Mariana requested, to form one cohesive track.

Approaching the end of the therapeutic process, Mariana acknowledged that she was not yet at the end of the hallway, but there was a light guiding her path forward. Throughout the process, the hallway was used as a referential image for symbolic processing but also as a tool for the therapist to orient Mariana to the present moment. Even if work was done looking to the past, it was important to leave sessions oriented in the present and facing forward in the hallway.

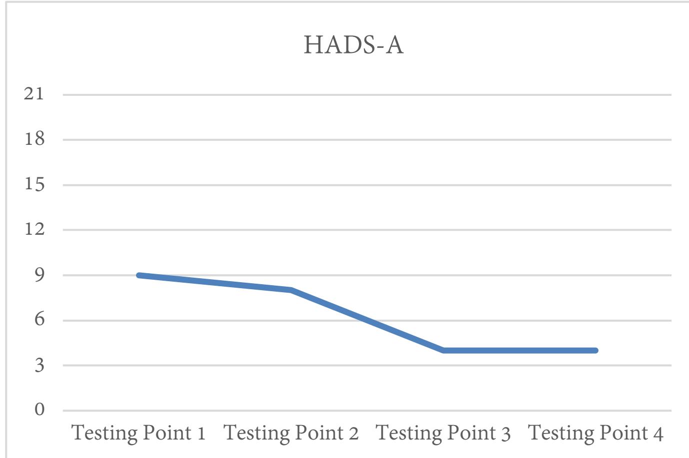
At the end of the therapeutic process, Mariana was left facing forward, present in the moment, and confident in herself to move forward independently. The final clinical report completed by the music therapist noted significant development in her ability to integrate imagery, memories, verbal and nonverbal communication, and real-life experiences. This integration combined with an increase of self-confidence allowed Mariana to develop strategies and personal goals that she had been able to implement to her everyday life.

Quantitative Outcome Measures

To effectively supplement the case profile outlined above, quantitative outcome measures will be presented to add additional perspectives to the study. The outcome measures consisted of HADS, MADRS, DES II, RAND-36, and visual analog scales (VAS).

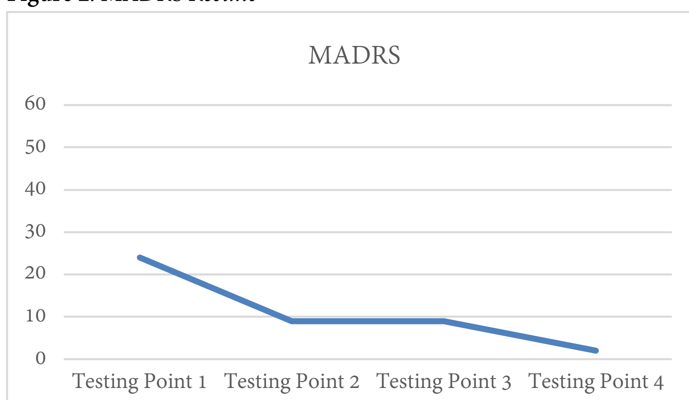
The authors of HADS have suggested threshold values for HADS-A (0-7 = normal range, 8-10 = presence of the state, >11 = likely presence of a mood disorder) [30]. Results of the current study indicate the presence of anxiety during the first two testing points, with scores then falling within the normal range for the remaining two testing points, as seen in Figure 1.

Figure 1: *HADS-A Results*



There have been proposed score ranges of MADRS reflecting the severity of depression (9-17 = mild, 18-34 = moderate, and >35 = severe) [18]. Current results reveal a decrease in depression levels over the four testing points. The patient's results of testing point one indicated moderate levels of depression, which decreased further below the mild level (see Figure 2).

Figure 2*: MADRS Results*



For the aims of this study, DES was not used as an initial screening tool since dissociation was a symptom of FND and not a pathological diagnosis. Rather, the DES was employed at the four testing points to monitor the symptom and to better profile the patient's experience with the symptom.

Results of the DES total mean score and the DES subcategories are displayed below in Figures 3 and 4. Higher scores indicate more occurrences of dissociative symptoms. In terms of monitoring the experience of the symptom, results from the total mean scores in this case indicates a decrease in dissociative symptoms. Initial scores of subcategories indicate the higher levels of absorption/imaginative involvement and amnesic dissociation than depersonalization/derealization

Figure 3: *DES Results*

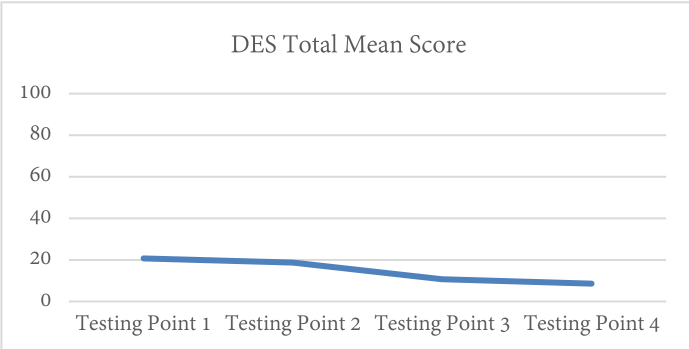
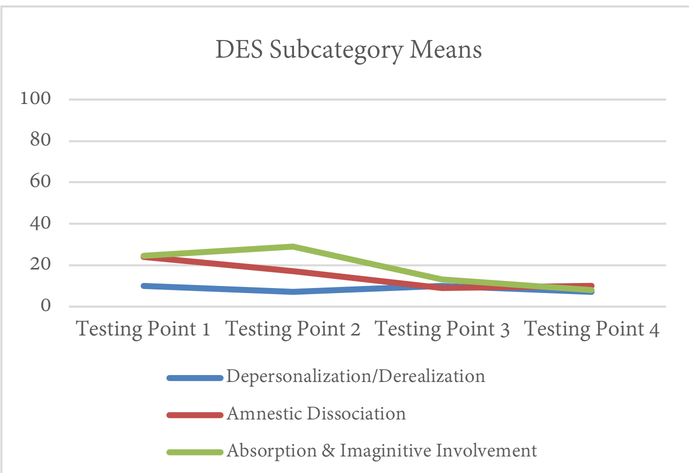


Figure 4: *DES Subcategory Results*



Items of DES that were scored the highest (50% or above) at testing point 1 include item 9 (Amnestic Dissociation), and items 14, 15, and 22 (Absorption and Imaginative Involvement). Item 21 (Absorption and Imaginative Involvement) increased at testing point 2 to 60%. Data for these items throughout the four testing points are seen in Table 3.

Table 3: *High scoring items (>50% occurrence in the previous week) of DES results*

Item	Testing Point 1	Testing Point 2	Testing Point 3	Testing Point 4
9. Some people find that they have no memory for some important events in their lives (for example, a wedding or graduation).	**70%**	20%	10%	20%
14. Some people have the experience of sometimes remembering a past event so vividly that they feel as if they were reliving that event.	**70%**	40%	40%	20%
15. Some people have the experience of not being sure whether things that they remember happening really did happen or whether they just dreamed them.	**50%**	30%	10%	10%
22. Some people find that in one situation they may act so differently compared with another situation that they feel almost as if they were different people.	**50%**	30%	10%	0%
21. Some people sometimes find that when they are alone they talk out loud to themselves.	20%	**60%**	20%	30%

RAND-36 scores have been presented with items from the mental health dimension and physical health dimension in Figures 5 and 6. A higher score indicates a higher health-related quality of life. Scores in the mental health dimension saw an overall increase, indicating an increase of quality of life in regard to mental health. Scores in the physical health dimension did not alter much, with exception to the energy levels.

Figure 5: *RAND-36 Mental Health Dimension Results*

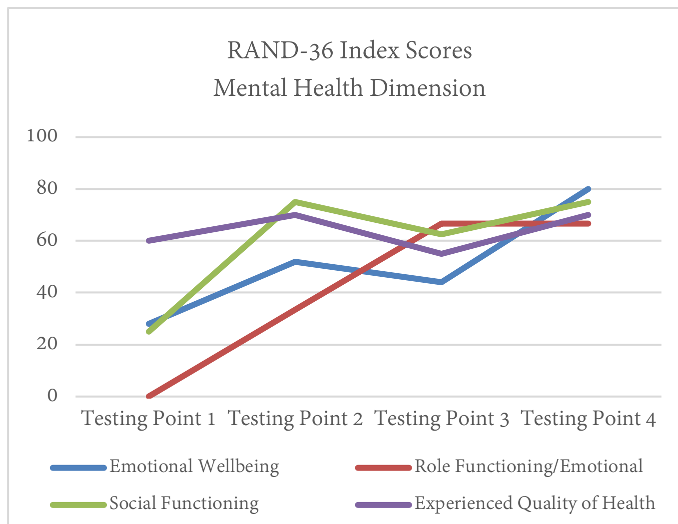
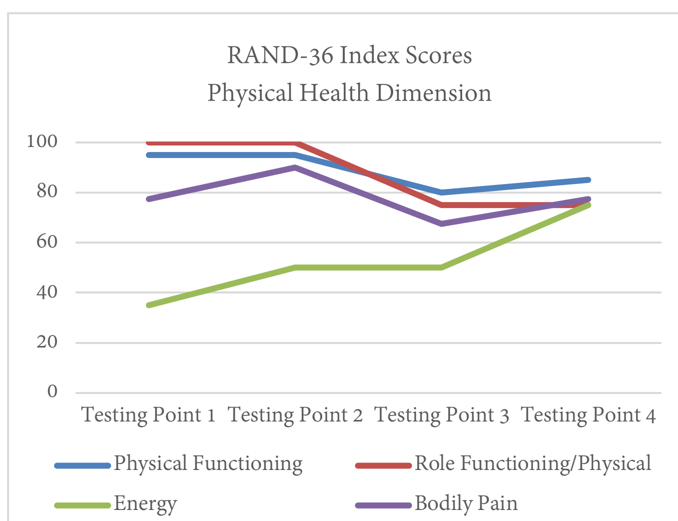


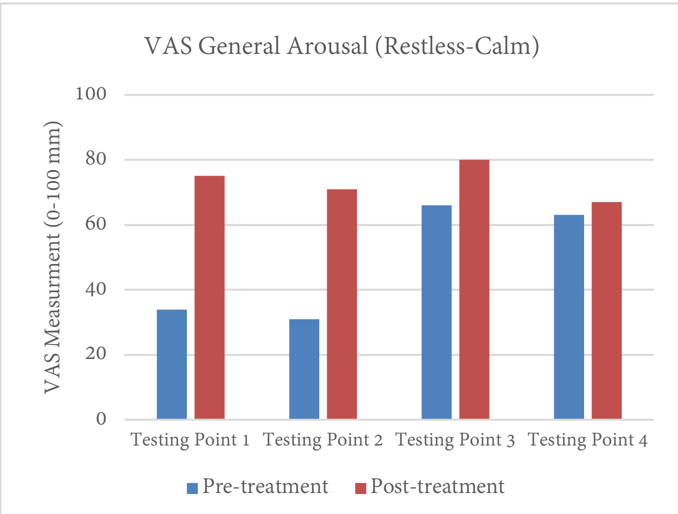
Figure 6: *RAND-36 Physical Health Dimension Results*



Visual analog scales were completed pre- and post-vibroacoustic treatment during the first and last sessions of phases one and two. The results for general arousal, mood, relaxation, and quality of life are presented below.

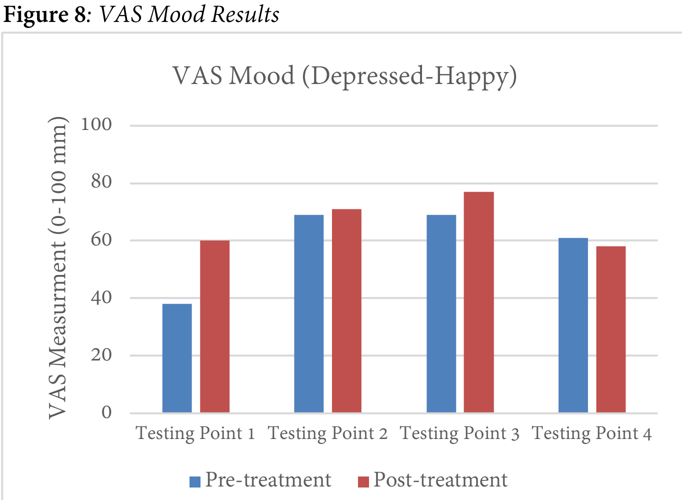
General arousal levels (Figure 7) indicate that the patient was calmer post-VAT. Large differences of 41 points and 40 points between pre- and post-treatment ratings can be seen for testing points 1 and 2, respectively. There were smaller differences pre- and post-treatment seen in testing points 3 and 4, likely due to the higher general arousal level ratings pre-treatment. There was a notable 35-point difference between the pre-treatment scores of testing points 2 and 3.

Figure 7: *VAS General Arousal Results*



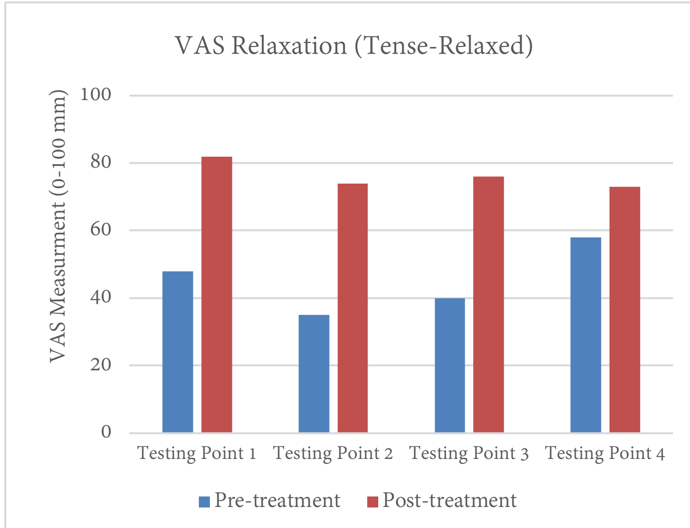
Mood levels (Figure 8) were slightly increased post-VAT for the majority of testing points, and overall levels were consistent with the decrease in depression levels, indicating an increase in mood levels over the therapeutic process. In comparing scores pre-treatment to post-treatment, 3 out of 4 testing points saw very small differences. However, testing point one saw a difference of 22 points pre- and post-treatment. The starting points for mood levels saw an overall increase of 23 points from testing point 1 to testing point 4.

Figure 8: *VAS Mood Results*



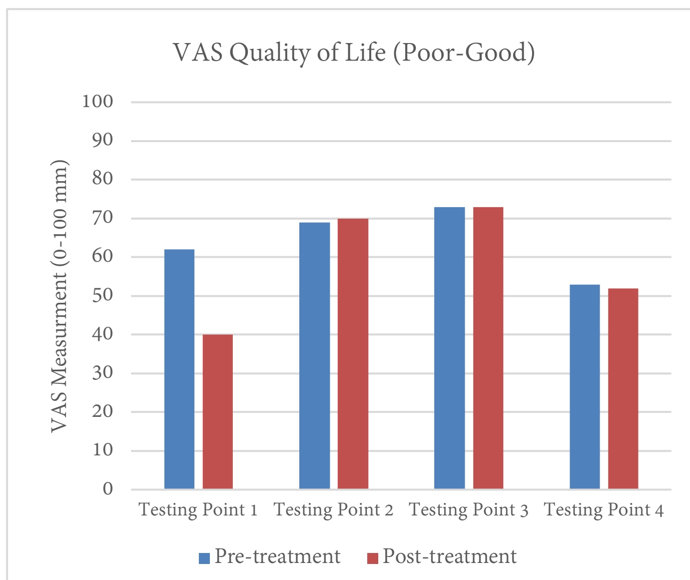
Differences in relaxation levels pre- and post-VAT are shown in Figure 9. As the chart shows, it was common during the assessment phase and working phase of therapy for the patient to be quite tense at the beginnings of sessions, but this factor improved through the course of therapy. Results indicate that the patient was consistently more relaxed after the 20-minute VAT.

Figure 9: *VAS Relaxation Results*



Quality of life scores remain consistent pre- and post-VAT, with exception to testing point one, as seen in Figure 10

Figure 10: *VAS Quality of Life Results*



Discussion

For this pilot study, the different types of data work to fulfill the case; to paint a more complete picture. The data are not meant to be compared or contrasted, but rather to lend to each other to form a better understanding of the patient and their experiences in this treatment protocol, and interactions with their FND diagnosis over a period of time.

The inclusion of washout periods in the case schedule allowed for the researcher to monitor any maintenance of effects. Results of the standardized inventories conducted after the first washout provided the therapist with a new baseline, indicating that the time away from therapy did not cause a dramatic break in functioning levels, and that work towards clinical aims could essentially start from where things were left at the end of phase one. The maintenance of effects seen after both washouts could point to potential longevity of the interventions, and/or demonstrate the patient's implementation of learned tools and strategies outside of the therapeutic environment.

The outcomes from the first testing point provided some insight into the patient's complex diagnosis and comorbid symptoms. These initial quantitative outcomes were not shared with the music therapist so as to not influence the music therapy assessment. While the quantitative outcomes provided some perspectives of the patient, the clinical assessment completed by the music therapist complimented this quantitative material and allowed the researchers to achieve a multidimensional profile of the patient.

The patient's profile changed over time as her experience with symptoms changed, and as work progressed towards her therapeutic aims. These key changes can be seen in the therapist's clinical notes and observations, but also through the patient's responses to the questionnaires at the four testing points. Overall scores and threshold values were taken into consideration, but responses to individual items also helped contribute to the patient's profile and her individual experience of various symptoms.

When considering the results from the DES, insight to the patient's experience of dissociative symptoms was gained by looking at her responses to each item. These items provided awareness to the patient's experience of dissociative symptoms outside of sessions and were not necessarily observed by the therapist in this case. In fact, the majority of dissociative symptoms observed regularly during sessions by the therapist were the patient's experiences of depersonalization and derealization, which was the subcategory of DES with the lowest scores. Without the two parallel assessment methods, the researcher would not have known about the variety of the patient's experience of dissociative symptoms inside and outside of the clinic.

RAND-36 scores for the [blinded] general population are available in the paper by Aalto, Aro, & Teperi [23]. Using the results, we are able to compare the patient's results with the national average results for women in her age range (25-29). Generally, the patient's results were below the average (indicating a lower quality of life than the national average), and the scores increased to be close to (if not surpassing) the average scores. The index scores for emotional wellbeing, energy, and role functioning/emotional can be seen in Table 4, comparing the national average scores with the scores which saw the greatest increases from the first and last testing points in this case.

Table 4: *RAND-36 National average index scores and index scores from this case (0-100)*

RAND-36 Index	National Average: Females age 25 – 29	Testing Point 1	Testing Point 4
Emotional Wellbeing	71.7	28	80
Energy	62.8	35	75
Role Functioning/Emotional	77.9	0	66.67

As the patient's emotional wellbeing and energy levels increased, her everyday activities were less impacted by her emotional health. Though the role functioning/emotional index score was still below the national average at the final testing point, the results indicate a substantial change in her ability to participate in everyday life activities.

The processing of thoughts, images, memories, bodily sensations, and emotions experienced during VAT [9] put the patient in vulnerable moments throughout the therapeutic process. These moments are indicative of the imperative establishment of safety within the therapeutic relationship [24]. Based on comorbidities and risk factors associated with FND, the likelihood of processing complex and emotional material can be expected [2,3,5]. This points to the central role of the therapeutic relationship and the work that stems from it [24], which is why a psychotherapeutically oriented approach to therapy was utilized in this treatment model.

The importance of a multimodal treatment in order to address psychological and physiological needs of FND patients has been documented [5,31]. In this case, VAT was not exclusively used to relieve physiological symptoms but was still fundamental to the patient's individualised treatment plan. During VAT, the patient was able to access new memories, encounter complex and emotional imagery, and experience depersonalization and derealization symptoms in a safe environment. Over time, she was able to detach feelings of anxiety and panic from these dissociative symptoms – even applying this coping tool to occurrences of the symptoms outside of therapy sessions.

Looking at the therapeutic approaches and methods used in this protocol, not only was the VAT portion multimodal by definition – treating physiological and psychological needs simultaneously – but the protocol utilized multiple modalities and approaches to music therapy. In addition, having all approaches of the treatment protocol rooted in a psychotherapeutic orientation provided a consistent theoretical perspective and consistency with a current treatment recommendation for FND [1,5,7,32,33]. In this case, clinical improvisation was used as an active music therapy approach in order to process referenced material on another level. Even though the patient in this case was able to process material relatively well on a verbal level, there was benefit in processing these same themes on a nonverbal level. Working at a symbolic distance in this case allowed the patient to safely explore these images and emotions with the support and guidance of the therapist [34]. By processing material on a verbal level and on a symbolic level using music, the patient was often able to access even deeper material than she had verbally, and gain confidence in her emotional expression.

Limitations

The original schedule of the study indicated an additional set of questionnaires to be administered immediately prior to the first washout period. Due to unforeseen personal circumstances and scheduling conflicts surrounding holidays, this appointment had to be cancelled. The researcher cannot definitively provide rationale for the improvement of questionnaire scores seen after washout periods, but the change in scores could be a reflection of the coping tools learned during therapy, and their implementation in the patient's everyday life. This aspect of the research is a clear example of the limited interpretative power inherent in single case studies.

Conclusions

This pilot study aimed to utilize a psychotherapeutically oriented approach to vibroacoustic therapy for patients with FND in order to propose a mind-body treatment for a mind-body disorder. The treatment plan ensured flexibility to address the range of functional symptoms that one with FND may experience and maintained the individualized nature of music therapy. Through the use of clinical observation, documentation, observation, video review, and quantitative outcome measures, a comprehensive conceptualization of the case was possible, which offered multiple perspectives to inform the protocol and the profile of the patient.

Current FND literature outlines the importance of an interdisciplinary approach to the diagnosis and treatment of FND [5,7,31,32,33]. The proposed treatment protocol bridges the current recommendations, is diverse in its approaches, and individualized to the patient. In this case study, the results were positive. The patient saw a reduction of dissociative symptoms over the therapeutic process which continued after the final washout period and learned strategies that she was able to implement outside of therapy to prevent the progression of further symptoms. The results of this pilot study warrant future research in order to refine a clinical model for patients with FND utilizing a multimodal approach which contains flexibility within its elements to fit patients' individual needs. The comprehensive range of data that was collected in this study allowed the researcher to formulate a holistic profile of the patient, with multiple perspectives on her experiences with her diagnosis of FND, and to better understand the dynamic features of these experiences over time. This knowledge resulted in a potential treatment protocol for this clinical population with positive implications for further investigation. Future avenues for investigation include further development of the treatment protocol, defining specific assessment elements in regard to this population, and investigating the profiles of FND patients and applying this knowledge to current diagnostic and treatment practices.

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Full-Length Article

How a child with a disability became a Nobel Prize winner: Hugo Theorell (1903 - 1982) and his music

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Abstract

Hugo Theorell was born in 1903. He was awarded the Nobel Prize in Medicine in 1955. His life, filled with music, illustrates how a child who became disabled by poliomyelitis at the age of three used violin playing as an important stimulus throughout life, and how music helped him become a world-famous scientist

Keywords*: Poliomyelitis, violin playing, brain development, emotion handling* multilingual abstract | **mmd.iammonline.com**

Introduction

The Swede Hugo Theorell may not belong to the group of Nobel Prize winners with eternal world fame like Albert Einstein, Marie Curie or Louis Pasteur. However, his discoveries of important basic principles for oxygen transportation to cells were indeed ground-breaking and important for Biochemistry at the time.

He was awarded the Nobel Prize in Medicine and Physiology in 1955, but his most famous discovery was made already in 1934. It was about the fundamental collaboration between co-enzymes (often labelled vitamins) and apo-enzymes (big peptides). We learned that both have to be present, together labelled holo-enzyme, in order for a reaction to take place. They do not consume one another, however. His discovery was made on riboflavin, vitamin B2.

As a biochemist with most of his career developments ranging from the 1920’s to the 1960’s, technological skills were important for Hugo. With a focus on the three-dimensional structures of large molecules and techniques for ultracentrifugation, electrophoresis and electron spin resonance were developed. The successful biochemists at the time often had to construct the technical equipment utilized in their discoveries, and Hugo Theorell was no exception from that rule. A substantial part of his research was about cytochromes, a group of large molecules, all of which have to do with oxygen transportation, ranging from hemoglobin, to myoglobin, riboflavin and cytochromes.

One reason why Hugo Theorell became popular and famous in his own country was that he became disabled at the age of three due to poliomyelitis but managed to succeed in life despite that problem.

Childhood

Theorell´s life illustrates that music can influence a person´s trajectory in surprising ways. Music within his life exemplifies how its influence can be of an unexpected nature. When discussing music and health, we often assume simple chains of causality, but in fact, the chains can be very convoluted and difficult to trace despite being of major importance.

Hugo´s life actually started symbolically with the oratory *Creation* by Joseph Haydn performed in the dome in Linköping, a city in the middle south of Sweden. His mother, Armida, who was a professional pianist, trained at the Royal College of Music in Stockholm, played the continuo part when his father Ture sang the basso aria. Ture was a young physician who had spent a lot of time and energy in singing lessons and practicing in Uppsala during his years as a medical student. Both Armida and Ture grew up in large priest families where music-making was a necessary and joyfully stimulating part of life.

At the age of three Hugo was hit by poliomyelitis. In the acute phase he was paralyzed both in his arms and legs. When his father and another physician were examining him sharing their fearful comments, they were interrupted by Hugo who said: “*But I can move my eyes in any way*” a remarkable comment by a three-year old. After the acute phase of the illness, it turned out that his arms and hands were well-functioning. However, both legs were permanently affected, particularly the left one, so he had to go through orthopedic surgery during several periods of his childhood. As a result of

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these operations, he could walk but he had to throw his left foot forwards with each step, and both of his legs were weak – forcing him to use a stick when walking.

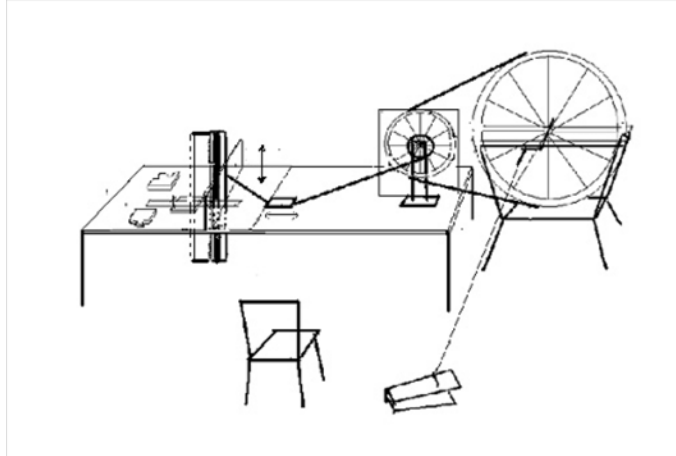
In a letter dated May 16, 1912 (when he was 8 years old), he wrote to his maternal grandparents the following:

[“Thank you for the fine violin! It will be a lot of fun to play on it now. Eva (older sister playing the piano) and I give concerts – it is resounding in the whole house!......I have a good time when I am sitting rolling around in my wheelchair. My pain is gone - which is good. In 2.5 weeks I shall be allowed to walk again. But I shall be forced to wear a supporting leather bandage for one more year. On the 3rd and 4th day of June I shall have examinations at school (his parents had been teaching him at home after the operation)…”]. [Translated from Swedish by the author. Quoted verbatim from handwritten letter possessed by Peter Hallberg, Uppsala, sister´s son of Hugo].

In this letter it also becomes obvious that music is playing an important part of this boy´s life – as a compensation for many activities that are impossible for him to participate in. For instance, he could not play football (which he regretted for all his life) with the other boys. His mother was an excellent piano player and his father was enthusiastic about Hugo´s playing. He had a violin teacher in the city, and in his teens he started travelling regularly to more advanced teachers in Norrköping and later to Stockholm. According to a concert program (June 1918) in Säbrå church (where his maternal grand father was vicar) he performed together with his mother at the piano the first two movements of Emil Sjögren´s (1853 – 1918) sonata (E minor) for violin and piano – advanced music for a 14-year old.

The other activity that consumed the boy Hugo was the construction of jigsaw puzzles. An engineering side of the boy became evident because he managed to construct a machine intended for industrial production. He changed the household sewing machine into a jigsaw which he could maneuver with his non-paralyzed foot. This made it possible for him to manufacture hundreds of jigsaw puzzles which he sold to friends and relatives. Over the years the income from this was substantial. In this way, he contributed to the payment of his own advanced musical education. His father (the main bread winner of the family) had been forced to take substantial loans during his medical education years because he had spent so much time on his singing. This resulted in a difficult family economy and Hugo´s own contribution was therefore of central importance.

Figure 1. *“Author” Henning Theorell´s drawing of jigsaw machine constructed by Hugo Theorell as a child*



Author's sketch of the young Hugo Theorell's home-made jigsaw machine, based on the description provided in his memoirs, *Changing Winds*.
Kindly provided by Henning Theorell

Medical studies and chamber music

At the age of 18, Hugo started his university education in Stockholm. Despite his childhood emphasis on music training and despite his strong engineering side, he chose the physician education at the Karolinska Institute. But he continued his violin playing and spent a lot of time touring all over Sweden with chamber music ensembles. They performed concerts in Stockholm and on the Swedish radio.

These young musicians were not afraid of the contemporary music of their time. In 1927, they had been asked to perform a string quartet which had been composed in 1921 by the Italian composer Alfredo Casella (1883-1947). The dominating music writer in Sweden at the time, Wilhelm Peterson Berger (1867-1942) – also a composer himself - wrote in the newspaper that this was ”torture music”-quite difficult to play.

Clearly Hugo´s violin playing had become even more advanced. As a young student he auditioned for a position in the Stockholm Academic Orchestra, an amateur orchestra for students and alumni at the universities in Stockholm. He played Pugnani Kreisler: Preludium and Allegro.

Scientific career

At that same time, Hugo had also started his scientific career. Already during the third semester of the medical studies (Chemistry) he was recruited to the department of Biochemistry as an assistant. The laboratory work delayed his clinical studies but in 1930 at the age of 27, he defended his PhD dissertation and also went through the last examination to become a physician. In 1932 he was appointed associate professor in the university city Uppsala north of Stockholm, and in 1933-1935 he was awarded a grant which made it possible for him to work with the famous German biochemist and Nobel Prize winner Otto Warburg who was running a large laboratory in Berlin. Since Warburg was Jewish he was under threat but the regime did not dare to hurt him because of his international fame. During his two years with Warburg, Hugo Theorell made his own big discovery, the collaboration between co-enzyme and apo-enzyme (see above).

In 1936, he became head of the biochemical department at the Nobel Institute in Stockholm. This was an independent research institute with considerable financial support from the Rockefeller Foundation. Sweden did not participate in the second world war, and additionally, Hugo did not have to participate in the military service because of his walking disability. This allowed him to work full-time as a biochemist during and after the war. This contributed to the fact that researchers from the US, Japan, Belgium, Russia, Hungary, Germany, Great Britain , Egypt and other countries were recruited to his department, and an innovative environment developed. Hugo received the Nobel Prize himself in 1955, and several of his collaborators were subsequently awarded Nobel Prizes (Feodor Lynen 1964, Christian Anfinsen 1972, Christian de Duve 1974, Sune Bergström 1982).

Figure 2. Left: Hugo Theorell in his lab. Upper right: Hugo Theorell inspecting Electron Spin Resonance machine. Lower right: Hugo Theorell on Swedish stamp

During these years Hugo Theorell showed a strong devotion to his membership in the Mazer quartet society, a club of mainly amateur (but also professional) musicians who loved chamber music. This society had organized chamber music evenings every Monday since 1849. There is a protocol showing exactly what was being played and by whom. During the years 1923 to 1973 when Hugo Theorell was in his active years in the society he was recorded as a musician in more than 600 performances – more than once every month during these 5 decades.

Hugo was a member of the board of the Stockholm Concert House between 1946 and 1973. During those years, he was chairman from 1951 to 1973.

Participation in the scientific world (congresses, laboratory work abroad, his own international collaborators in his laboratory) led him to contacts with other researchers, some of them Nobel prize winners, who also played instruments. The musical fellowship stimulated the scientific collaboration. One example is Ernst Boris Chain (1906-1979) who grew up in Germany and had Jewish, Russian ancestors. He aimed at becoming a concert pianist but also studied Chemistry. In 1933 he had to flee from Germany to England. All of his close relatives were killed by the nazis. In England he decided to devote his professional life to biochemistry. He was awarded the Nobel prize in 1935 together with Florey and Fleming for their discovery of penicillin. Ernst Chain had a longlasting biochemical collaboration with Hugo Theorell and they performed many experiments together in a joint collaboration with the Swedish drug company Astra. But they also played together many times. Chain played 7 times in the Mazer society between 1946 and 1961 (Beethoven, Brahms, Bach, Schubert, Dvorak).

When Hugo traveled he spent much more time during a trip than scientists do today. Not only did he lecture in conferences, he also spent a substantial amount of time conducting experiments with his colleagues. Travelling was slower and the tradition for a biochemist was that one should stay and also do some experimental work together with foreign colleagues. Since Hugo had his walking difficulties it was always self-evident that his wife Margit, a professional pianist and harpsichord player, travelled with him. This gave them many opportunities to play chamber music for instance in England and in the US. The solo cellist in the Los Angeles Symphony Orchestra, Villy van den Burg, played with Margit and Hugo when they were in Los Angeles. The three played piano trios for several hours together. Afterwards Hugo received a letter from Villy van den Burg with the following words:

["I have also played with other Nobel prize winners, among them Albert Einstein. But I must say that you play much better than he does, both his rhythm and his pitch are as relative as his theory."] [Quoted verbatim from Hugo Theorell´s collection of letters, now in the Royal Library in Stockholm]

Application of modern music science to Hugo Theorell

There are several studies showing that the development of brain areas which guide the specific work of the fingers in instrument playing is stimulated by intensive music training. In one of them Hyde et al (1) studied 6-year old children. Fifteen of them were randomly selected to have intensive education in piano (keyboard) playing for 15 months while 16 received no such training during that period. Electromagnetic resonance imaging showed that the children´s brains in the two groups did not differ at start but after two years there were clear differences.

Brain areas associated with finger functions had been developed much more clearly in the instrument training group than in the control group. These studies were of great importance when they were published because previous studies had shown that there were differences of this nature between the brains in professional musicians and non-musicians but it was not known whether the differences were inborn or a result of the extensive music training itself.

For the first time there were studies showing that music training in small children is indeed associated with these kinds of changes in the brain. More specific studies have shown that violinist brains have more developed areas related to the function of the left hand (right hemisphere) whereas pianist brains have more advanced brain areas on the other side – which clearly mirrors the fact that violinists have more difficult work to do with their left hand whereas the opposite is true of pianists.

However, there was still critique against the brain studies – even after the introduction of random control trials. How could we know that the brains of the more talented children were not the ones who developed with this kind of stimulus? Therefore, it was very important when de Manzano and Ullén (2) did a brain study of 9 pairs of monozygotic twins aged 27-54.

The members of these pairs had had a contrasting experience: One in each pair had played piano extensively throughout life whereas the identical twin sibling had no such experience – these pairs were *piano discordant*. In such a study it is impossible to blame possible differences observed in the brain on genetic factors. And indeed, the results from the magnetic resonance imaging analyses showed that the piano playing twin had more of both white (connections between nerve cells) and grey (the nerve cells themselves) substance in relevant areas, namely in the areas corresponding to motoric functions of the fingers (in particular the left hemisphere), the small brain (general coordination of movements), the connections between hearing and emotion and finally the corpus callosum which is the main connection between the left and the right hemisphere. Corpus callosum is very important for the coordination between the right and the left hand for a musician but it is also very important for emotional functions which are of course central in music making (3).

There has also been a discussion regarding possible effects of early music training on cognitive ability (mathematics and language skills). (See for instance 4). That seems to be more frequently debated among researchers. Moreno et al (5) were among the first researchers who published studies in which small children were randomly selected to instrument training. Swaminathan and Schellenberg have summarized this research (6) and their conclusion has been that there may be a small positive effect on cognitive development but that this has been shown to be attenuated after a while, perhaps if the instrument training is not continued.

There do appear to be correlations between the three aspects of musicality (melody, rhythm and pitch) on one hand, and general IQ on the other hand (0.25, 0.30 and 0.27 respectively (7). These correlations are to a great extent genetically determined so they do not provide any convincing support for an improved cognitive ability as a *consequence* of early music training. On the basis of the Swedish twin study the heritability (amount of variation that could be attributed to genetic factors) was calculated to be 58, 50 and 39% respectively for these three musicality aspects. This means that ability to recognize melodies seemed to be more genetically determined than pitch. However, from multivariate analysis it is clear that boys who have a good pitch are more likely than other boys to work in a creative occupation in the future. Hugo may be an example of this (7).

Not unexpectedly the childhood environment can be of great significance for continued playing in adult years for a child who starts extra music training during the school years. Childhood factors that increased the likelihood of continued playing among subjects who were 27-54 years old at the time of the examination were examined in multivariate analysis (8). Childhood factors that increased the likelihood of adult playing were early start, many people among friends and family members who practiced music, many experiences of cultural performances in general, own choice of instrument (or singing), ensemble playing, playing by ear, classical music or pop, lessons more often than once a week and completely positive attitude in parents. Young Hugo had all of these factors influencing him. It is difficult to clearly point at causal factors in this web of associations since genetic factors may play a role in all of them. However, modern research based upon twins shows that excellence in music practice arises when there is a favorable interplay between genetic and environmental factors. The higher level of skill, the more pronounced the importance of this interplay (9).

Social and emotional competence

An important aspect of leadership in the scientific world - which builds its work on complicated collaborative efforts - is emotional and social competence.

Hugo Theorell´s sociability has been described by many of his collaborators. The department of biochemistry at the Medical Nobel Institute was a large operation with collaborators from many countries with widely diverse cultural experiences. We could imagine the differences between Russian, Japanese, Egyptian, Scottish, French, German and American scientists.

The relationship between extensive musical practice on one hand and ability to differentiate, describe and communicate emotions (the opposite of alexithymia, *inability* to differentiate, verbalize and communicate emotions) on the other has been examined in a large twin study in Sweden. This study (10) showed that both in men and women there was a dose-response relationship between amount of music practice that a person had had in life and his/her ability to handle emotions - the more music training the less problem with emotions. The study also showed that ensemble playing amplified this relationship. As mentioned above, early music training seems to stimulate the growth of the frontal part of the corpus callosum, the link between the right and the left hemisphere of the brain. This link is of central importance to emotion handling (3) - although the link between music practice and emotion handling is also to a large extent pleiotropic, which means genetically determined.

Hugo literally used his music in order to increase the feeling of togetherness in his institute. Twice a year all the staff – including janitors, laboratory assistants, animal keepers and scientists from all of the countries were invited to participate in large parties. At Christmas, the singing of Christmas songs was organized with small children singing solos and Hugo playing his violin. At mid-summer the partying was even more extensive because all the staff were invited to Margit´s and Hugo´s summer place in the Archipelago outside Stockholm where everybody was invited to play garden games but also sing all the Swedish Midsummer songs with Hugo playing his violin.

Conclusion

Hugo Theorell's case exemplifies how a strong interest in music with intensive stimulation from a music family can compensate for a handicap. It is argued that his intensive music training might have stimulated emotional and social competence that proved valuable in his role as leader of a large scientific institution with scientists from the whole world. This social competence facilitated collaboration with other science groups and was amplified by opportunities to play chamber music with scientists. It is impossible to know in an individual case whether music training has contributed to cognitive skills since genetic factors contribute both to musical competence and cognition, but interaction between a family background with strong music emphasis and inborn talent for science may have been important.

The interplay between music and science in his life is illustrated by a response he gave to a journalist when he had received the Nobel Prize:

Question: "*Is there a conflict between music and science in your life?*" Response: "*No, quite the opposite: When my scientific activity is not working well, I perform some music and then the science works better!*"

[Interview on Swedish Television 1955, available in STV Archives]

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Biographical Statements

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Full-Length Article

Effects of music on behavior and the cardiovascular system in animals and human beings

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Abstract

Background: Music plays an important role during the lifetime. However, little is known about whether music of different styles can directly alter behavioral patterns in animals or cardiovascular parameters in human beings.
Objective: To study the potential effects of classical music (CL) and heavy metal (HM) in comparison to silence (S) on behavioral patterns or cardiovascular parameters blood pressure (BP) and heart rate (HR).
Methods: Behavioral patterns were examined in six German Large White pigs. Cortisol levels, heart rate and blood pressures were recorded in 60 healthy volunteers. In animals and human beings an identical study protocol was used. In both groups, CL (Bach, Suite No. 3, BWV 1068), HM (Disturbed, Indestructible) and S were applied. Duration of sound exposure of CL, HM or the S period was 21 minutes. All data of the studied volunteers were compared to 60 healthy "control" (CO) participants who underwent an identical study protocol but without music application ("silence", S).
Results: In animals, we clearly could demonstrate that CL leads to significantly more activity and attention of the pigs (e, g. playing ball) compared to HM or S ($p<0.001$). In contrast, HM was significantly more associated with unexpected, stress-related behavioral patterns (excitation, trying to escape) compared to CL or S ($p<0.001$). In humans, systolic, diastolic BP (mm Hg) and HR (beats per min) decreased mostly when CL was played compared to HM or controls ($p<0.001$), prior to and after sound exposure.
Conclusions: The results provide evidence for the potential of music styles to improve or diminish welfare in this farm animal species. It is obvious that CL (Bach) leads to both positive behavioral patterns in animals and decreased values of BP and HR. In HM or S, we could not observe similar findings. Therefore, according to these experimental and clinical data, sound exposure with classical music had positive effects on cardiovascular parameters and will positively influence behavioral patterns in animals.

Keywords: ***Animal welfare, classical music, heavy metal music, blood pressure, heart rate, cortisol***

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Introduction

There are several individual reactions to music that are dependent on individual preferences, mood or emotions [1, 2]. It has been reported that musical perception is associated with modulation in heart rate, heart rate variability, blood pressure, body temperature, perspiration, respiration and muscle tension [3-5]. There are several controlled prospective studies published that clearly demonstrated the beneficial effects of music in clinical medicine [6-11]. Several parameters like pain, stress, anxiety and cardiovascular parameters were positively influenced by music application [12, 13]. The mechanisms of these effects are still unclear. It is not known whether the effects of music on different clinical and experimental parameters are visible in the same way in animals and in humans. To answer this question it seems reasonable to study the same music compositions with an identical study protocol in both groups. In addition, it has been reported that classical music has positive effects on cardiovascular parameters in humans and in rats, whereas nothing is known what happened when listening to modern music like heavy metal. The purpose of the present prospective randomized study was to compare completely different music styles with an identical study design in animals and humans.

Methods

The present prospective randomized study was divided into two parts: an animal study group and a study group with healthy volunteers. Both study groups had an identical study design, with participants listening to classical music (Johann Sebastian Bach: Suite No. 3 D major, BWV 1068) and to heavy metal music (Disturbed: Indestructible) compared to controls with silence. The animal study was proven by the Ethics Committee of the Justus-Liebig-University Giessen with the

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reference number V 54 19c 20 15 (1) Gl 18/15 No 86-2010. The human study was approved by the Ethics committee of the Ruhr-University Bochum according to the ICH-GCP guidelines. All volunteers provided written, informed consent to participate (Ruhr-University Bochum, Register-No: 3898-11). The study was registered in the German Clinical Trials Register (DRKS 00009835). The purpose of the animal study was to analyze the effect of different music styles on behavior; cardiovascular parameters were of no interest because an invasive blood pressure measurement was not allowed by the Ethics Committee. In the human being study, the effect of different music styles on cardiovascular parameters was the main topic, whereas the influence of volunteer's behavior by music or silence was not the focus.

Study protocol in both study groups

In both studies, an identical protocol with the same music compositions was used to compare the effects of music in animals and in humans. This has never been done before and therefore, we present results of a pilot study. Since there has never been described such a comparison of identical music styles in humans and animals, both studies were presented together. The music was selected by one of the authors (HJT). The selection of "Bach's music" was guided by a published scientific suggestion with a random list of classical music pieces: studies by Bernardi 2006 and 2009 have shown the best effects (i.e. on blood pressure, heart rate) on Bach's music [3, 5]. Heavy metal music was also selected in a scientific way by one of the authors (HJT). Recours et al [14] and Drew [15] reported on negative health effects when listening to heavy metal music. Therefore, this music was selected as an opposite part to classical music also from a random list of heavy metal pieces.

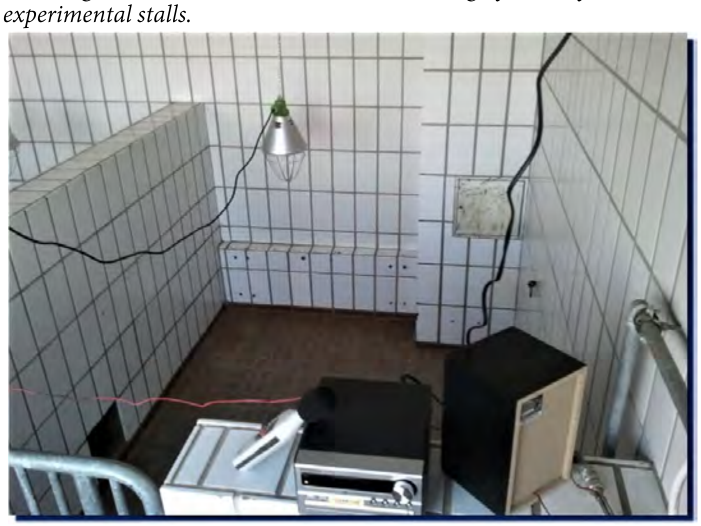
Studied music

Classical music: The Suite No. 3, D-major, from Johann Sebastian Bach (BWV 1068) consisted of five different parts: "Ouverture", "Air", "Gavotte", "Bourée" and "Gigue". The duration of the suite is 21 min. Heavy metal: Indestructible is the fourth studio album by the American heavy metal band Disturbed. Indestructible was recorded at Groovemaster Studios in Chicago, Illinois and released on june 3, 2008. The album was certified platinum by the Recording Industry Association of America in april 2009 for shipping over 1,000,000 copies in the United States. The single "Inside the Fire" was nominated for a 2009 grammy award in the "Best Hard Rock Performance" category. Duration of heavy metal music application was 21 min.

Animal study

Six healthy male pigs of the German Large White breed at the age of 7 weeks were included in this prospective randomized study. After birth the animals first spent on the farm and then were moved to the Department of Veterinary Clinical Sciences, Justus-Liebig-University Giessen. None of the pigs had contact with noise or music prior to the study. This was necessary to exclude any form of conditioning. The pigs were acclimatized to housing conditions for two weeks, before the experiments were started. At the beginning of our experiments, all pigs consecutively passed three stations. All animals were randomized to classical music, heavy metal music or silence due to an occasional way and experiments were performed in the same environment. All pigs were housed together in two connected 6 m^2 tiled boxes on straw beddings. Food and water were provided ad libitum. Pigs were fed a customary cereal diet (energy content 11.5 MJ/kg) without food additives. During the experiment, pigs were moved to three identical, neighboring stalls, each with two separated boxes. Each box was provided with one pig. The two pigs of one stall had acoustic, optic (through an opening in the separating wall between the boxes) and olfactory contact with each other, but they were unable to interact physically. Single experiments continued for exactly 21 minutes. Since this was a pilot study that had never been carried out before, we only planned the experiments with six animals.

Figure 1. *Study box with a customary CD-player, connected to two 5 Watt speaker boxes.The pig's behavior was recorded in real-time by a wide-angle lens camera, centered at the ceiling of each of the three experimental stalls.*



Specific study protocol in animals

Study music was presented via a customary CD-player (Panasonic SC PM02EG S connected to two 5 Watt speaker boxes) at approximate volumes of 40 db, 60 db and 70 db (controlled by a SL-100 sound-level measuring device (Voltcraft, Germany). The pigs' behavior was recorded in real-time by a wide-angle lens camera, centered at the ceiling of each of the three experimental stalls (Fig. 1). The cameras gave full overview over both boxes of the stalls. The signals were routed by LAN to a personal computer (IBM, Munich, Germany) in a control room located next to the experimental stations. Behavioral patterns were assessed from the screen of the PC by one person, after all recordings were finished. For each pig in each experimental period, the start and the ending of any different behavior was clocked and extracted. Frequency and duration of each behavioral activity as well as the total duration of each behavior during the 21 minutes experimental period were analyzed. The study with all experiments lasted a total of four months.

Human study
All participants were randomized to classical music, heavy metal music or silence. Studies were performed in all participants on consecutive days starting every day at 9.15 a.m. All volunteers received a 12-lead surface electrocardiogram (GE Marquette MAC 1200), Holter recordings (PhysioQuant, Fa. Envitec) and continuous blood pressure recorders (Pathfinder-system, Fa. Spacelab Healthcare) or the Lifecard CF system (Fa. DelMar Reynolds GmbH). In all participants, after a silence period of 30-45 min, study music was presented via stereo headphones (Fa. Philips, Einthoven, The Netherlands) plugged into an mp3-player (Odays S-8 2 GB, S-15, Fa. Odys) at 10.00 a.m.. The volume level of the music/noise recordings was kept exactly 60 db through the study. During our experiments, subjects were in a lying position. During baseline and music presentation, the subjects were told to close their eyes and concentrate on the music.

Statistical analysis
Paired sample t-tests were subsequently performed to evaluate differences between measurements taken before and after listening to music or silence. Wilcoxon's test and Mann-Whitney-U test were applied to determine the differences before, during, and after listening to music or silence due to non-normally distributed data. Other used tests are the Shapiro-Wilk-test and the Bowkers test. In the animal study, data were not normally distributed and zero was a common value (if a behavior was not shown during a single experiment). Thus data analysis was based on non-parametric tests. Differences between music-styles (no music [silence], heavy metal, classical music), repeat days were treated as repeated tests. Overall significances were tested with the Friedman test (variances of ranks). If significant, pairs were tested with Wilcoxon signed-rank test for two related samples. Dichotomous data were analysed with Fishers exact test. All analyses were done with IBM-SPSS, Version 20, IBM, Munich, Germany. P-values less than 0.05 were considered significant.

Results

Influence of music on behavioral patterns in animals
We could identify 24 behavioral patterns at least once during the total observation period (Table 1). Without music (silence, i.e. control group), most of the time, pigs spent in recumbency (26.4%), followed by digging in the straw beddings (21.7%). Minor activities were listening, digging while lying, drinking and walking (going). Sniffing, ear clapping, shaking head, playing the drinking trough, scratching, eating, defecation, micturition, standing still or in the trough, and sitting were shown only sporadically. When the pigs were exposed to classical music, stress-related patterns were reduced to the level of silence (Table 2).

Table 1: *Behavioral patterns observed in the pigs during the study*

Synonym	Description
Banging into wall	banging head into the wall
Climbing wall	trying to climb up the wall
Crashing into wall	running and crushing into the wall
Defecation	Defecation
Digging	digging with head in straw bedding
Digging in trough	digging movements with nose in the trough
Digging while lying	digging movements during recumbency
Drinking	water absorption
Ear clapping	movements with ears
Eating	Ingestion
Excitation	fast rotation of the pig around the mid of ist body
Flight under trough	trying to flight under the trough
Frighted lying	recumbency with eyes wide open, obviously stressed
Getting frightened	interruption of a behaviour by sudden frighted abidance
Going	unstressed walking
Listening	active listening, standing still, raising head, concentrating on sounds
Micturition	Micturition
Playing ball	active contacting and nudging of a playing ball
Playing with drinking trough	active playing with snout in drinking trough, no drinking
Recumbency	unstressed lying
Scratching	scratching the body with hind legs
Seizures	pig developing conculsions
Shaking head	shaking the head
Sitting	sitting on the floor
Sniffling	sniffling, movment of nostrils
Standing in trough	standing with front legs in trough
Standing still	standing still without any further activity

Table 2: *Comparison of different behavioral patterns to music in animals when listening to classical music, Heavy Metal or silence (control group)*

	HM vs CO	CL vs CO	HM vs CL
Banging into wall	***	ns	***
Defacation	*	ns	*
Digging	***	***	ns
Digging in the trough	***	ns	***
Digging while lying	***	ns	***
Drinking	ns	**	ns
Ear clapping	***	**	***
Eating	***	***	***
Excitation	**	ns	**
Flight under trough	***	ns	***
Frighted lying	***	ns	***
Getting frightened	***	ns	7uu
Going	**	***	ns
Listening	***	***	ns
Micturition	ns	*	ns
Playing ball	***	***	***
Recumbency	***	ns	***
Scratching	ns	**	***
Seizures	ns	ns	ns
Shaking head	***	**	***
Sitting	**	ns	***
Sniffing	***	***	ns
Standing in trough	***	***	***
Standing still	***	***	ns

Abbreviations: CO=control group (silence), CL=classical music, HM=heavy metal
*$p<0.05$, **$p\leq0.01$, ***$p\leq0.001$

However, total activity and attention of the pigs were further increased, especially by listening, going, sniffing and playing ball. Recumbency was significantly reduced. When the same pigs were exposed to heavy metal music, behavioral patterns changed significantly. Time spent in recumbency decreased, while the pigs spent more time listening, standing still or in trough, going, ear clapping and sitting. Thus, the total activity of the pigs increased significantly ($p<0.05$). At the same time, new and unexpected behavioral patterns appeared, especially patterns that could be related to stress, like frightened lying, excitation, crashing into the wall, attempts to flight under trough and even seizures. There were significant differences in behavioral patterns between classical music, heavy metal or silence ($p<0.05$). In addition, there were significant differences in the duration of behavioral patterns while listening to classical music, heavy metal or controls (Table 3).

Table 3. *Percentage of total duration of behavioral patterns during the 21 observation time. Data are expressed as medians, 75% and 95% percentiles.*

		CO	CL
Recumbency	**Median**	**26,39**[ab]	**0,00**[b]
	P75	98,21	44,76
	P95	100,00	99,96
Digging	**Median**	**21,71**	**35,16**
	P75	45,24	50,58
	P95	77,70	76,45
Listening	**Median**	**3,33**[a]	**20,91**[a]
	P75	7,54	36,79
	P95	24,19	60,38
Digging while lying	**Median**	**3,25**[a]	**0,00**[ab]
	P75	20,20	3,08
	P95	64,76	26,69
Drinking	**Median**	**0,79**	**0,95**
	P75	2,00	2,38
	P95	4,31	4,84
Going	**Median**	**0,28**[ab]	**1,19**[b]
	P75	1,11	2,34
	P95	2,58	12,98
Sniffing	**Median**	**0,00**[a]	**1,15**[a]
	P75	2,36	5,81
	P95	5,67	13,37
Ear clapping	**Median**	**0,00**[ab]	**0,08**[b]
	P75	0,16	0,60
	P95	4,56	7,62
Shaking head	**Median**	**0,00**	**0,00**[a]
	P75	0,08	0,08
	P95	7,14	0,38
Banging into wall	**Median**	**0,00**	**0,00**
	P75	0,22	0,00
	P95	5,79	3,15
Playing ball	**Median**	**0,00**[a]	**0,00**[a]
	P75	0,00	1,11
	P95	0,00	20,26
Scratching	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	0,08	3,13
Climbing wall	**Median**	**0,00**[a]	**0,00**[a]
	P75	0,00	0,16

	P95	0,24	0,56
Eating	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	17,58	0,00
Defecation	**Median**	**0,00**	**0,00[a]**
	P75	0,00	0,00
	P95	2,38	0,62
Micturition	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	1,41	0,71
Getting frightened	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	0,00	0,00
Digging in trough	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	0,00	0,00
Standing still	**Median**	**0,00[ab]**	**0,00[b]**
	P75	0,00	3,19
	P95	3,81	9,19
Standing in trough	**Median**	**0,00[a]**	**0,00**
	P75	0,00	0,00
	P95	0,71	0,00
Frighted lying	**Median**	**0,00[a]**	**0,00[b]**
	P75	0,00	0,00
	P95	0,00	0,00
Sitting	**Median**	**0,00[a]**	**0,00[b]**
	P75	0,00	0,00
	P95	2,76	0,14
Exzitation	**Median**	**0,00[a]**	**0,00[b]**
	P75	0,00	0,00
	P95	0,00	0,00
Flight under trough	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	0,00	0,00
Seizures	**Median**	**0,00**	**0,00**
	P75	0,00	0,00
	P95	0,00	0,00

Significances: Values with the same letter are significantly different on a p ≤ 0.05 level.

Stress-related and activity-relates behavioral patterns in animals

Some of the observed behaviors were clearly "stress-related", while others seemed to be clearly related to activity. Others were hardly to decide. To provide deeper insight into stress- or activity-relatedness of a distinct behavior, each of them was analyzed by factor analysis.

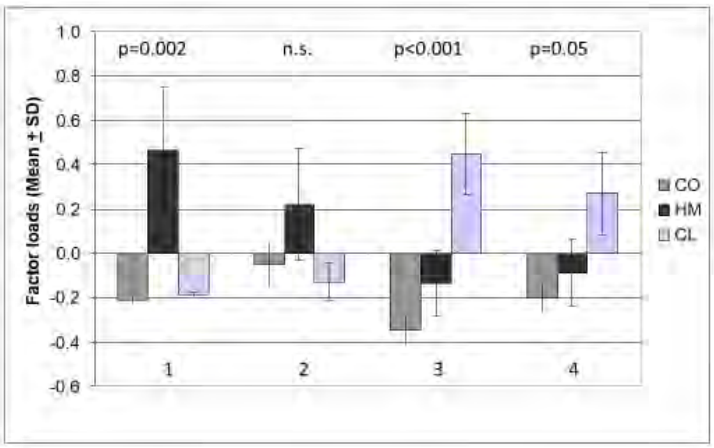
Factor analysis rendered four factors (Table 4). Factor 1 showed clearly evidence of stress-related to the patterns of excitation, seizures, crashing into the wall and frightened lying loading especially to this factor. Also, digging in trough and sitting were best grouped to factor one, a potential indication of their relatedness to stress during this experiment.

Table 4. *Results of a factor analysis of the behavioral patterns as shown during the 21 minutes observation interval. Data are sorted within components by decreasing loads.*

Factors	Components 1	2	3	4
Excitation	,924			
Seizures	,877			
Digging in trough	,809			
Crashing into wall	,516			
Srightened lying	,371			
Sitting	,268			
Standing in trough		,794		
Defecation		,759		
Flight under trough		,682		
Micturition		,601		
Sniffing		,493		,338
Playing ball		,310		
Eating		,276		,202
Going			,779	
Climbing wall			,655	
Scratching			,656	
Listening			,608	,422
Standing still			,446	
Ear clapping			,335	
Banging into wall			,268	
Digging while lying			-,264	
Recumbency				-,802
Digging				,769
Drinking				,628
Playing drinking trough				,274
Getting frightened				
Shaking head				

Factor 2 was composed of activity patterns with stress-related components like flight under trough and eventually defecation and micturition. Other activity-related patterns were formed to factor 3. Finally, factor 4 was negatively loaded by recumbency and positively by e.g. digging, listening and playing the drinking trough, which were activity related patterns. We could demonstrate that without music (silence, control group), pigs showed below average representation of each of the factors. Under heavy metal, stress-related factors one and two were overrepresented and the more activity-related factors three and four were underrepresented. Influenced by classical music, the stress-related factors showed a similar shape as without music, while the activity-related factors were significantly dominating (Fig. 2).

Figure 2. *Factor loads in relation with different music styles. Factors 1 and 2 represent mainly stress-related behavioral patterns, factors 3 and 4 represent mainly activity related patterns.*



Human study group and controls
The human study has been presented in detail in the journal "Music & Medicine" [16]. However, some findings should be repeated briefly for better understanding and to compare the effects of different music genres in animals and in humans.

Study population and controls
Sixty healthy volunteers (30 males, 30 females) with a mean age of 46.1±12.6 years (range 25-75 years) were included in this prospective randomized study. All participants listened to classical music and heavy metal music. Sixty volunteers (30 males, 30 females) with a mean age of 44.7±13.8 years (range 25-75 years) were matched to the study group and served as controls with silence during the study period. There were no significant differences between study group and controls prior to entry into the study. No significant differences were observed between both groups for age (p=0.569), height (p=0.849), weight (p=0.521), body mass index BMI (p=0.520), systolic blood pressure (p=0.991), diastolic blood pressure (p=0.130) and heart rate (p=0.971). All 120 volunteers had no history of heart disease or hypertension and no history of neurological or psychiatric conditions. All participants were drug-free with normal values of blood pressure (RR <140/90 mm Hg), heart rate (60-100/min) according to the guidelines of the European Society of Hypertension (ESH) and of the European Society of Cardiology [17]. Physical examination and 12-lead surface electrocardiogram was normal in all of them. All humans were asked which music they normally most enjoy. There was no "favorite" music visible. In addition, nobody of them had experience with Bach's orchestral suite No. 3 or Disturbed's heavy metal music.

Study measurements
Exactly at 10.00 a.m. blood test was performed to measure the cortisol level prior to music lexposure (or silence) to evaluate "stress" of the volunteers. Ten o'clock was choosen because at this time there is the lowest physiologic cortisol movement within 24 hours. After the end of music application (or silence) another blood test for cortisol measurement was performed. Before and after participants listened to music, blood pressures and heart rates were recorded in a silent situation. Then, the music was started and blood pressures and heart rates were recorded every five minutes for a period of 60 min. After one hour, measurements were done every 15 min until 1.00 p.m. After listening to music, another blood test for cortisol measurement was performed.

Results

Cortisol measurements
Cortisol levels decreased significantly when listening to classical music (10.3±4.6 µg/ml, range 7.0-23.7 µg/ml)(p<0.001), heavy metal music (10.6±4.4 µg/ml, range 7.6-26.1 µg/ml) or controls (12.2±4.5 µg/ml, range 3.6-27.7 µg/ml)(p<0.001). There were no significant differences in the cortisol levels between control group and volunteers who listened to Bach (p=0.583) or Disturbed (p=0.274) (Table 5).

Table 5. *Changes in serum cortisol concentrations as a result of exposure to the music of Bach, Heavy Metal, compared with controls*

	Bach	Heavy Metal	Silence
Baseline (Mean value±SD (range))	12.4 ±5.3 (6.0-31.8)	12.4 ±5.3 (6.0-31.8)	14.6±5.4 (6.2-31.0)
Difference after versus before exposure to music (µg/dL)	-2.2 (±4.5)	-1.9 (±3.8)	-2.4 (±3.5)
95%-confidence interval for mean	[-3.3;-1.0]	[-2.8;-0.9]	[-3.3;-1.5]
p-value for comparison after versus before exposure to music*	<0.001[2]	<0.001[1]	<0.001[1]
p-value for comparison music versus silence**	0.573[2]	0.235[2]	

*[1]t-Test; [2]Wilcoxon- signed rank test
** Mann-Whitney-U-Test

Blood pressures

Significant differences were noted in systolic blood pressure before and after listening to classical music (mean 128.3±11.3 mm Hg, range 107-138 mm Hg) before and 120.8±12.6 mm Hg (range 100-163 mm Hg) when listening of music (p<0,001). In addition, also significant differences were noted in diastolic blood pressure before and after listening to classical music (mean 81.9±7.9 mm Hg, range 61-94 mm Hg) before and 77.0±9.0 mm Hg (range 55-101 mm Hg) when listening to classical music (p<0,001). Listening to heavy metal music, significant differences were noted in systolic blood pressure before (mean 123.5±11.6 mm Hg, range 100-145 mm Hg) and 119.9±10.4 mm Hg, range 99-141 mm Hg) when listening to Disturbed (p<0,001). In addition, significant differences were noted in diastolic blood pressure before (mean 79.7±9.0 mm Hg, range 58-103 mm Hg) and 77.0±6.8 mm Hg, range 63-93 mm Hg) when listening to heavy metal music (p=0.004). It is interesting to note that we observed similar effects on blood pressures in controls: significant differences were noted in systolic blood pressure before (mean 123.0±11.2 mm Hg, range 99-146 mm Hg) and 120.6±8.7 mm Hg (range 100-163 mm Hg) during the silence study period (p=0.016). In addition, similar differences were noted in diastolic blood pressure before (mean 77.4±7.9 mm Hg, range 62-99 mm Hg) and 75.4±5.5 mm Hg (range 55-101 mm Hg) during silence time (p=0.081)(Tables 6,7).

Table 6. *Changes in systolic pressure under exposure to the music of Bach or Heavy Metal, compared with controls.*

	Bach	Heavy Metal	Silence
Baseline (Mean value±SD (range))	128.3±11.3 (107-138)	123.5±11.6 (100-145)	123.0±11.2 (99-146)+
Difference after versus before exposure to music (mm Hg)	-7.5±9.1	-3.6±7.1	-2.3±7.2
95%-confidence interval for mean	[-9.8;-5.2]	[-5.5;-1.8]	[-4.2;-0.5]
p-value for comparison after versus before exposure to music*	<0.001[1]	<0.001[2]	0.016[1]
p-value for comparison music versus silence**	<0.001[1]	0.189[2]	

*[1]t-test; [2]Wilcoxon-signed rank test
**Mann-Whitney-U-Test

Table 7: *Changes in diastolic pressure under exposure to the music of Bach or Heavy Metal, compared with controls.*

	Bach	Heavy Metal	Silence
Baseline (Mean value±SD (range))	81.9±7.9 (61-94)	79.7±9.0 (58-103)	77.4±7.9 (62-99)
Difference after versus before exposure to music (mm Hg)	-4.9 (±7.5)	-2.7 (±6.9)	-2.0 (±7.3)
95%-confidence interval for mean	[-6.8;-2.9]	[-4.4;-0.9]	[-3.9;-0.1]
p-value for comparison after versus before exposure to music*	<0.001[2]	0.004[1]	0.081[2]
p-value for comparison music versus silence**	0.007[2]	0.168[2]	

*[1]t-test; [2]Wilcoxon signed rank test
**Mann-Whitney-U-Test

Heart rate

Significant differences were noted in heart rate before (mean heart rate 75.3±12.0 bpm, range 55-90 bpm) and during (mean heart rate 67.8±8.4 bpm (range 53-86 bpm) classical music. (p<0,001). After the end of exposure to Bach, heart rate increased significantly to 78.4±11.9 bpm (range 58-113 bpm)(p<0.001). In heavy metal music, heart rate decreased from 72.5±11.3 bpm (range 52-98 bpm) to 66.6±9.4 bpm (range 53-90 bpm)(p<0.001). After heavy metal music application, heart rate increased significantly to 79.2±12.4 bpm (range 54-109 bpm)(p<0.001)(Table 8).

Table 8: *Changes in heart rate during (min^{-1}) exposure to the music of Bach or Heavy Metal, compared with controls.*

	Bach	Heavy Metal	Silence
Baseline (Mean value±SD (range))	75.3±12.0 (55-90)	72.5±11.3 (52-98)	70.4±14.0 (52-139)
Difference after versus before exposure to music (min^{-1})	-7.4 (±10.2)	-5.9 (±9.0)	-5.8 (±12.3)
95%-confidence interval for mean	[-10.1;-4.8]	[-8.2;-3.6]	[-9.0;-2.6]
p-value for comparison after versus before exposure to music*	<0.001[1]	<0.001[1]	<0.001[2]
p-value for comparison music versus silence**	0.030[2]	0.345[2]	

*[1]t-test; [2]Wilcoxon signed rank test
**Mann-Whitney-U-Test

Discussion

To the best of our knowledge, this is the first prospective randomized study that analyzed the influence of different music styles in animals and human beings. It is very important that both study groups, animals and humans, underwent the same study protocol. It is necessary to stress that we intended to analyze the different effects of music styles on behavioral patterns in young piglets to see whether effects are independent factors or not. Because those observations are impossible in humans, in this study, the focus was to analyze the effects of different music styles on cardiovascular parameters.

Animal study
The present study showed significant direct effects of exposure to music on the behavior of pigs. There has been some work published, pointing out the welfare benefits of certain styles of music, in the sense of environmental enrichment [18, 19]. However, the scientific background is widely lacking. One effect might be the masking of background music to negative acoustic stimuli in the environment of the animals [20]. If this was the exclusive effect of music, different genres and styles should provoke the same effects. However, differences in music style, speed, tempo, vocal vs. instrumental music, etc., have shown different effects on different behaviors, including aggression, agitation and social affiliations [20]. Bearing this aspect in mind, we decided to use two music styles, classical music and heavy metal music that, regarding music theory, show pronounced differences. Moreover, the pigs were housed in a quiet environment without disturbing or unknown background noises.

Classical music or heavy metal in animals
Indeed, the different effects of both music styles were confirmed. Both music styles caused significant increase of the pigs' activity, when compared to the behavior of the same pigs without music. However, the application of heavy metal music resulted in the onset of stress-related behavior, e.g. seizures, frightened lying, excitation, crashing into the wall and others [21]. Thus, heavy metal music clearly diminished the welfare of the pigs. This effect happened at moderate volumes and could not be anticipated in this form before the experiment, although there are reports of chickens responding to music with fearful behaviors [22]. The occurrence of excitation and seizures during exposure to heavy metal music points towards activation of a wide pattern of brain activity and a subcortical connection to the hypothalamic-pituitary-adrenal axis as described for noise-induced stress [23]. On the other hand, with a significant reduction of recumbency and the non-appearance of directly stress-related behavior, other activities increased during classical music. Behaviors like digging, playing ball and playing drinking trough can generally be interpreted as positive behavior [24]. Such positive behavior has been increased by classical music in the present study. Other activity-related behavioral patterns, e.g. listening, sniffing and standing still can be interpreted as a reaction of the pigs to the music.

Conditioning
In general, a possible effect of music on animals might be due to conditioning. De Jonge et al. proved that music can indeed be used as an effective context conditioning tool to facilitate positive, rewarding behavior in pigs [25]. However, they also found that also the piglets of the control group, whose experience with music was not conditioning, did also show enhanced activity during music replay. This result confirms the findings of the present study, where conditioning could be excluded, because the pigs never heard any music before the experiment! This is one of the most important findings of the present study. Moreover, conditioning effects of the repeats during the experiment could be excluded, because they were not linked to any special activity. As regards any conditioning effect of heavy metal music during the second week on the behavior during classical music of the third week, especially with regard to fear or stress, stress-related behavior was fully reduced during classical music to the situation of the first week without any music.

Biochemical effects
Another possible mechanism comes from growing evidence that music might indeed directly modulate several neurological and cardiac functions and trigger biochemical effects [26]. Thus, direct stimulating, positive and negative effects of music on the organism are possible, although the molecular basis of this context is still lacking, especially in animals. Studies on animals (e.g. young chicks) indicate that musical stimulation have measurable effects on their behaviors and brain chemistries, especially increased brain norepinephrine turnover [27]. There are other reports that described effects of music on neurochemical parameters, in the avain brain of young socially housed as well as isolated chicks [28, 29].

Conclusions for effects of music on aggressive behavior or pig interaction cannot be drawn from the present results, because the pigs were not able to interact during the experiment, although they could hear, see and smell each other. Further research is needed to provide more insight in this highly interesting additional topic.

Effect of music in animals: what is important to know?
The present study showed significant direct effects of exposure to music on the behavior of pigs. It has been shown that differences in music style, speed, tempo, vocal vs. instrumental music, etc., had various effects on animal behaviors, including aggression, agitation and social affiliations [30,31]. Several authors evaluated the experimental evidence for synchronization to a musical bean in a

nonhuman animal [32-34]. Bearing this aspect in mind, we decided to use two music styles, classical music and heavy metal music that show pronounced differences. The pigs were housed in a quiet environment without disturbing or unknown background noises. Indeed, the different effects of both music styles were confirmed. Both styles caused significant increase of the pigs´ activity, when compared to the behavior of the same pigs without music. However, the application of heavy metal music resulted in the onset of stress-related behavior, e.g. excitation, banging the wall and running [35]. Thus, heavy metal music clearly diminished the welfare of the pigs. This effect happened at a moderate volume of 60db and could not be anticipated in this form before the experiment, although a tendency of chicken to react more fearful on music has been reported.

The occurrence of excitation and seizures during the exposure to heavy metal music point towards the activation of a wide pattern of brain activity and a subcortical connection to the hypothalamic-pituitary-adrenal axis, as described for noise-induced stress. On the other hand, with a significant reduction of recumbence and the non-appearance of directly stress-related behavior, other activities increased during classical music. Behaviors like digging, playing ball and playing drinking trough can generally be interpreted as positive behavior [36]. Such positive behavior has been increased by classical music in the present study. Other activity-related behavioral patterns, e.g. listening, sniffing and standing still can be interpreted as a reaction of the pigs to the music of Bach. However, it is not clear, whether this behavior should be interpreted in the sense of meeting the demands of curiosity and thus, as a positive enrichment, or in the sense of upcoming fear. Another possible mechanism comes from growing evidence that music might indeed directly modulate several neurological and cardiac functions and trigger biochemical effects. Thus, direct stimulating, positive and negative effects of music on the organism are possible, although the molecular basis of this context is still lacking, especially in animals.

Effects of music on the cardiovascular system in humans

Bernardi et al. [3] studied 24 young, healthy subjects (12 chorists and 12 nonmusician control subjects), 25±1 years of age, matched for age and sex; 12 (25±2 years old, 9 females) were experienced chorists (at least 3 years). The 12 control subjects (24±1 years old, 7 women) had no previous music training. They all listened in random order to music with vocal (Puccini's "Turandot") or orchestral (Beethoven's Ninth Symphony adagio) progressive crescendos, more uniform emphasis (Bach's Cantata BWV 169 "Gott soll allein mein Herz haben"), 10-second period rhythmic phrases (Verdi's arias "Va pensiero" and "Libiam nei lieti calci") or silence while heart rate, respiration, blood pressure, middle cerebral artery flow velocity, and skin vasomotion were recorded. Vocal and orchestral crescendos produced significant correlations between cardiovascular or respiratory signals and musical profile, particularly skin vasoconstriction and blood pressures, proportional to crescendo, in contrast to uniform emphasis, which induced skin vasodilation and reduction in blood pressure (p<0.05). Correlations were significant both in individual and group-averaged signals (p<0.05). It has been shown in other studies that music will have beneficial effects on heart rate, heart rate variability and anxiety levels in not only skilled pianists but also nonmusicians during both performance of and listening to music [37, 38]. The findings of the different studies suggest, though, that musical performance has a greater effect on emotion-related modulation in cardiac autonomic nerve activity than musical perception [39]. A meta-analysis reported significant decreases in heart rate, blood pressure, respiratory volume, oxygen saturation, cortisol, and basal state when listening to different music styles compared to controls [38].

Ninety-two RCTs (7385 patients) were included in the systematic review, of which 81 were included in the meta-analysis. Music interventions significantly decreased anxiety (MD -0·69, 95 per cent c.i. -0·88 to -0·50; P < 0·001) and pain (MD -0·50, -0·66 to -0·34; P < 0·001) compared with controls, equivalent to a decrease of 21 mm for anxiety and 10 mm for pain on a 100-mm visual analogue scale. Changes in outcome corrected for baseline were even larger: MD -1·41 (-1·89 to -0·94; P < 0·001) for anxiety and -0·54 (-0·93 to -0·15; P = 0·006) for pain. Music interventions provided during general anaesthesia significantly decreased pain compared with that in controls (MD -0·41, -0·64 to -0·18; P < 0·001)[40].

Influence of music on cortisol-levels in humans

Nilsson et al. [41] analyzed the follow-up of 58 patients after cardiac surgery. These patients underwent musical therapy (30 min music exposure one day after surgery) compared to controls. Evaluation of cortisol, heart rate, ventilation, blood pressure, SaO_2, pain and anxiety indices were performed. There were significantly lower cortisol levels in the music group (484.4 mmol/l) compared to patients without music (618,8 mmol/l) (p<0.02). There were no significant differences in heart rate, blood pressure, respiration and oxygen saturation between both groups. Similar effects have been reported by Antonietti in patients who underwent rehabilitation after surgery [42]. In our study, we could also demonstrate that cortisol levels decreased during music exposure. However, this was not specific and observed when listening to classical music, heavy metal music or silence. Therefore, it seems necessary to postulate that the observation of decreased cortisol levels are physiological (although we performed the test in all participants at 10.00 a.m.). It is not possible to conclude anything from the observations of decreased cortisol levels while listening to music, various sounds or silence.

Conclusions

Although there are many observations and explanations about the effects of music, many data are very poor and incomplete - more myth than science! One of the most important results of the present study is the influence of music in young pigs: we could clearly demonstrate that Bach's music leads to a "positive" behavioral pattern, whereas heavy metal was associated with stress and a "negative" pattern. The results provide clear evidence for the potential of music-styles to improve or deteriorate welfare in this farm animal species.

Without music, the pigs that had been accustomed to their new housing system for two weeks, before the investigation started, showed a relatively inactive behavior without remarkable stress-related behavior. Taken together, music of different styles showed significantly positive and negative effects on pigs that were quantified based on behavioral patterns. To rule out general statements on the benefits of music on pigs as a method to increase environmental enrichment and thus animal welfare, more research including more styles, more breeds and more individuals is needed. Since there are no similar study results in pigs are available so far, the definitive meaning of our presented results is unclear. Further investigations on animals are necessary to show the definitive importance of our investigations. In humans, there is a beneficial effect on blood pressure and heart rate visible when listening to classical music. In the meantime, additional reports with beneficial effects on cardiovascular parameters with other composers (W.A.Mozart, J. Strauss jun.) are available [43].

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Full-Length Article

Group singing programs for mental health and well-being: *an evaluation framework*

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Abstract

There is growing interest in the intersection of music and health, there is a lack of understanding of music's broader, multifaceted effects on health. Group singing, in particular, has been reported to have benefits on physical, mental, and social health; but interactions between different effects to improve overall health and well-being are not well understood. This paper evaluated group singing programs to develop a three-category framework through organizing raw data to trace interactions amongst various effects of participating in group singing activities. The research population was two programs based in the Royal Borough of Kensington and Chelsea (RBKC), London, UK meant to meet demands for community-serving non-medical interventions: the *Sing to Live, Live to Sing* in 2016, an adult singing program based in community centers across RBKC, and the *(G)uided (L)earning, (U)niting and (E)ducating (GLUE) Sings* program, an adolescent music-making and singing program piloted by RBKC's Tabernacle W11 in 2018. Both programs were found to improve the holistic well-being of participants. The three-category framework was useful in organizing data and showing interactions between effects of singing on health. The framework can be used in future research using mixed methodologies and increasing collaboration amongst funders, researchers, program managers, and policymakers.

Keywords*: music, evaluation framework, singing and health, well-being* multilingual abstract | **mmd.iammonline.com**

Introduction

Group singing impacts health in diverse ways [1]. Singing confers physical impacts, particularly in terms of breathing, although measured benefits are largely confined to those with respiratory diseases [2,3]. Other benefits include relaxation, better posture, and a sense of exercise from physical activity through attending sessions [4]. The link between group singing and mental health is more established [5]. Group singing has been reported to express and release negative emotions, thereby helping distract from worries and stresses [5,6]. Singing also has benefits for learning and cognition when increasing musical knowledge through improving vocal skills and learning to read music [4]. Additionally, group singing has well established social benefits, providing a platform for collaboration, collective bonding, and building friendships through a shared activity [4,5], and may offer an accepting and non-judgmental environment in which individuals can feel safe [6].

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These characteristics have led to group singing being used as a rehabilitative mechanism in medical regimens for holistic benefits on health, from helping asthma and other respiratory conditions [2-3] to implementation as an emotional outlet in depression and other mental illnesses [5]. Group singing is useful in helping those with trauma [6]. Communities can use singing to socialize and build ties as a group through composing lyrics and singing together, thereby developing stronger, healthier community bonds to create healthy publics [5,6]. These benefits of singing have been seen to affect all age groups, from teens to older individuals [4,8], thereby showing the broad evidence for music effects on holistic health, particularly emotional and social health

Most studies in the field have researched the impact of music on health by focusing on specific parameters, such as social skills, emotional well-being and physical improvements [1-9]. While there have been reports on interaction mechanisms of various effects for health and well-being [8-9], this has not been fully evaluated, making it difficult to create a foundation on which to build policies for implementing music interventions [10]. The call for frameworks in the area of arts and health has been growing [10,11]. A report by the WHO also highlighted the need for a framework regarding how physical, personal, and social benefits interlink and affect one another [1].

A health-arts thematic framework has been developed for the arts in general by Davies et al [11]. Given that group singing involves the intersection of physical, mental, and social impacts in a unique way within the arts, a framework specific for group singing is required to better understand its holistic effects on health. We aimed to undertake a qualitative study to develop a framework which conceptualizes the relationship between group singing and health. We also report on interactions and nuances highlighted when applying the framework to organize the effects of group singing on health.

Local Context

In the UK, local authorities have taken on the responsibility of public health and health promotion. The Royal Borough of Kensington and Chelsea (RBKC), in particular, is interested in effective non-medical interventions to reduce levels of poor health and inequalities; the borough has one of the highest proportions of the population living with severe mental illness in the UK, and some of its wards have significantly poorer average health compared to other London boroughs[12-13].

Methods

Two Group Singing Programs

A qualitative evaluation was conducted on two group singing programs. The programs were initiatives funded by the RBKC local council, the most granular level of local government responsible for service provision and overseen by the Arts Service and Public Health. Both programs were free of charge to enrollees and did not require prior singing experience. Participants were recruited through word of mouth and advertising in community centers. Instructors had experience in teaching group singing and songwriting in a holistically therapeutic way. Aimed towards RBKC adult residents, *Sing to Live, Live to Sing* addressed public health priorities of mental health and social isolation [14]. The workshops were all-inclusive, with two of the six tailored to those with specific health needs. The program held weekly two-hour sessions during the school day at local community centers. The *(G)uided (L)earning, (U)niting and (E)ducating (GLUE) Sings* program provided a community music-making experience for RBKC adolescents between 13 and 19 years old. The initiative was developed after the deaths of 72 local residents in the 2017 Grenfell Tower Fire had negative impacts on the whole community, leaving an intense need for services that rebuilt community support networks and increased well-being [12-13]. Over the course of eight weekly 1.5 hour-long workshops at the Tabernacle W11 in London, participants wrote and recorded a song for a group-chosen theme.

Data Collection

Researchers evaluated the programs using qualitative methods, attending sessions of *Sing to Live, Live to Sing* in May-July 2016 and *GLUE Sings* in May-July 2019. Program leaders and participants were told about the research, and consent was given via an “opt-out” mechanism, where upon explanation of the research, participants who did not want to take part in the study could opt out. Researchers attended the sessions for direct observation that enabled a holistic examination of the programs by situating interviews within the context of the program and its participants [15]. Researchers wrote notes to generate an account of each session.

We undertook semi-structured interviews with participants. Interview topic guides were adapted as research progressed to include issues raised by participants during data collection. For *Sing to Live, Live to Sing*, participants were recruited for interviews via purposive sampling to ensure inclusion of all workshops and participant diversity in age and gender. Interviewed participants had to have completed a ‘term’ of workshops prior to April 2016. All instructors were interviewed. Interviews took place before or after workshops, or at different times and locations depending on participant availability. For *GLUE Sings*, the focus group and interviews occurred at the end of the last session, allowing participants to speak about the entirety of the experience. Interviews complemented the focus group and allowed researchers to delve more deeply into, and to expand upon, themes and patterns. Documents, such as song lyrics, from the workshops were included in the analysis.

Data Handling and Storage

All interviews were audio-recorded. Recordings were deleted after transcription and the transcripts were stored securely. Participants were anonymously identified throughout the study while staff and stakeholders were identified only by titles.

Data Analysis

Interview transcripts and participant observation accounts were typed and uploaded to NVivo 10 for coding and organizing [16] in a thematic approach. Song lyrics from the *GLUE Sings* song were also uploaded and analyzed.

Transcripts and accounts were coded using an iterative thematic method, whereby open coding was used for emerging themes and concepts. Trends and patterns in the data were grouped into themes to create a conceptual framework. We then analyzed how different thematic components related to one another to disentangle links and mechanisms between different effects. Results were then charted onto a schematic diagram that showed the interactions and influences between observed effects, along with underlying mechanisms that led to these potential holistic benefits.

Ethics

Per the RBKC Council’s Business Insight, Analysis and Customer Engagement Team’s research governance framework, the Imperial College Research Ethics Committee (ICRWC) determined that the research did not require an IRB approval, as the project was a service evaluation to inform commissioning on future music intervention groups for promoting well-being. We obtained written, informed consent from all interviewees. All transcripts were anonymized with no personal identifying information included. Participant observation was done openly and any questions about the research were answered.

Results

Participant information of the adolescent (younger) group at *GLUE Sings* and the adult (older) group at *Sing to Live, Live to Sing* are given in Tables 1 and 2, respectively. A Logic Model of the programs based on the CDC Program Evaluation Logic Model [15] can be found in Appendix 1.

Table 1: *Table of Participants for GLUE Sings*

Age Distribution	***Age (years)***	***n***	***%***
	13-14	17	68%
	15-16	4	16%
	17-18	3	12%
	19	1	4%
Gender Distribution	**Gender**	**n**	**%**
	Male	11	44%
	Female	14	56%

Table 2: *Table of Participants in Sing to Live, Live to Sing*

Participant Type	Participant Number	Sing to Live, Live to Sing Workshop Number (number as location of workshop)	Gender	Interview Month
Program Participant	1	1	M	May 2016
	2	1	M	May 2016
	3	1	M	May 2016
	4	1	F	May 2016
	5	1	F	May 2016
	6	1	F	June 2016
	7	1	F	June 2016
	8	2	F	May 2016
	9	2	F	May 2016
	10	2	M	June 2016
	11	2	F	July 2016
	12	3	F	June 2016
	13	3	F	June 2016
	14	3	F	June 2016
	15	3	F	June 2016
	16	4	M	June 2016
Instructor	A	1	M	June 2016
	B	2	F	July 2016
	C	3	F	June 2016
	D	4	F	June 2016
Organizer	1	1	F	June 2016
	2	1	F	June 2016

Program operation and music-making

Both programs started sessions with warm-ups led by the coaches. Remaining time was spent rehearsing songs or writing lyrics in preparation of recording and performances.

The *Sing to Live, Live to Sing* cohort was diverse, especially in terms of ethnicity, although there were more women than men in all groups. Music was sung live by participants, generally a cappella or with the leader playing a piano. Songs were generally taught by ear, without sheet music, although lyric sheets were handed out. Songs were chosen by each workshop leader and comprised a wide spectrum of genres. Differences in repertoire can reflect the personal experiences and preferences of leaders. For example, one workshop they did "songs of the world" while another did generally gospel and soul music, reflecting the interests of the leaders. All leaders reported taking on song suggestions of their participants. However, it was difficult to determine to what extent suggestions were included in the repertoire. Based on one leader, songs were chosen in terms of personal joy in teaching the song and the perceived meaning of the song. Thus, while repertoire may reflect participant preferences, it is more influenced by the different leaders of the workshops. For a list of songs sung at the workshop, see Appendix 2.

In *GLUE Sings,* subjects wrote lyrics on a pre-chosen theme selected to inspire subjects to create an uplifting song: happiness and hope. Each subject wrote and recorded one stanza of the song. Subjects were walked through the writing process, starting with brainstorming phrases related to the theme, followed by putting together ideas to create a flowing stanza. An acquaintance of the vocal teacher created a unique sound mix for the subjects to use in their final product. Subjects recorded their parts at the Tabernacle's recording facilities after practicing their stanzas with the soundtrack. Tabernacle staff edited the recordings into one track against the main soundtrack to create the song. The lyrics of the song created by the subjects can be seen in Appendix 3. The song was performed at the Tabernacle's end-of-summer event.

Physical Impacts

The dominant physical impact described was regarding breathing. Instructors started sessions with breathing exercises, directing awareness to how the body produces sound or to mind-body control and alignment. A sense of improved posture and relief from back pain was also reported, predominantly in those aware of ongoing back pain or poor posture. Older-aged participants described improvements in their asthma and chronic obstructive pulmonary disease (COPD). Other participants felt *"relaxed and calmer,"* fostering a clarity of the mind that allowed for achievement of program goals. This demonstrated a link between physical effects of music-making and personal well-being.

Instructors used breathing games to engage participants in group social activities. Participants challenged each other to hold onto notes for longer time periods or to breath together, creating a sense of community through friendly competitions. Workshops also incorporated basic choreography into performances, encouraging physical activity. Participants talked animatedly, sharing ideas and laughing as they practiced the movements – a distinct change from the shy, minimal conversation at the beginning of the program, linking the physical and social effects of group music-making. Programs were said to *"[help] people to feel more structured when they are not. Giving people a focus, something to aim for. Many don't need this but there are a few that do."*

All physical outcomes may be influenced by the recurring theme of greater awareness and control of the body. This seems to occur in a spectrum across different workshops, ranging from specific awareness of how the body produces sound during singing to a more holistic awareness and control of the body and mind-body alignment.

Personal Impacts

In both programs, workshops provided participants with activities that structured their weekly schedule and opportunities for socialization. The nature of the song may have also engendered positive feelings as there was a focus on choosing uplifting material. Learning a new song or writing lyrics helped participants build a personal sense of growth and group belonging, thereby improving self-confidence. While there was initial embarrassment or self-consciousness of singing in front of peers, participants eventually overcame this nervous barrier. Learning song lyrics was also said to enhance participants' capacities to learn and memorize information.

Singing and song-making were found to relieve stress through serving as sources of emotional relief and stress-coping mechanisms. Participants found that workshops allowed them to escape and *"switch off from things going on at home"*. Distraction from problems also helped participants feel more positive. Workshops provided the social environment where participants can encourage each other to cope with external stresses.

Music-making served as an emotional outlet and a form of expression. Older participants said that singing certain songs could unlock memories. One participant who had emigrated from their home country described how certain songs made them nostalgic about their childhood or their home. This made them more positive, suggesting that reminiscing is a positive experience. Emotional engagement with the songs created an environment of social support, resulting in greater group bonding.

Table 3: *Example Lyrics from GLUE Sings*

Personal Benefit Seen	Lyrics
Emotional Expression of Stress and Insecurities	*Verse 4 lyrics from song: 'You can be strong in your body but not in your mind / You wonder why you're always left behind / You need to aim high to be first in line / You need to be quick because we don't have time'*
Expression of Resilience and Hope	*Last verse of lyrics: 'Strength and belief is all that you need / As we need to be strong and believe to achieve / To get our goals we use brain power / So we can fly high as high as a tower / Shine like a star show off your talent / But also be humble and keep your balance / Don't be afraid of what's to come / You'll make it there and it will be fun / Strength is the key to achieving your dreams / Don't be silly no need to mean'*

For the younger subjects in *GLUE Sings*, the process of songwriting provided an emotional outlet, allowing them to directly express their personal emotions, rather than solely relating to the lyrics of a pre-written song. The lyrics (Table 2) and brainstorming notes reflected struggles and insecurities that participants faced outside the workshop, including fears of being left behind and not improving fast enough. However, lyrics also showed signs of resilience and hope, where participants encouraged others to set goals and believe that they have the strength to reach them (Table 3).

3.4 Social Impacts

The social aspects of the workshops were one key reason that participants enjoyed the programs, with some explaining *"it's good to be around people."* For example, because the *GLUE Sings* program was not associated with one academic institution, participants (apart from a few sets of siblings) were from different schools and had never met before.

This extensive socialization and collective creation can lead to feeling valued and belonging in a group where their voices are heard, which can create positive feelings and a sense of achievement within the tea [5]. One participant noted that the song-making process was special and made her happy *"because you get to write it with your friends and write about what you want. And after you record it and it sounds good, you're proud of yourself."*

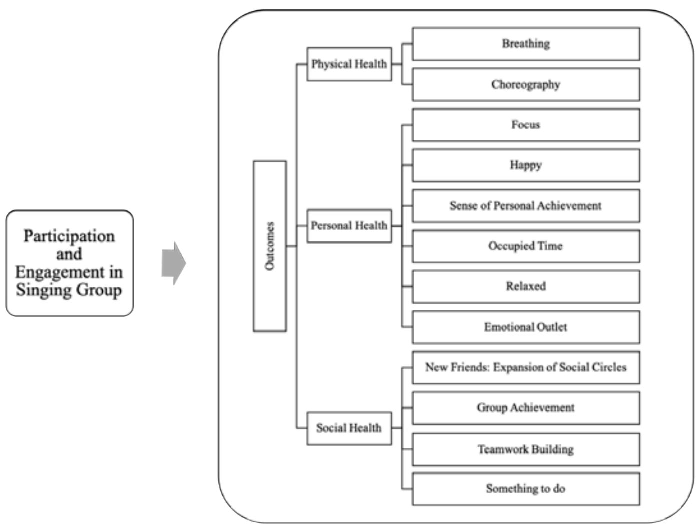
The friendly environment allowed participants to extend their social skills to become self-confident in themselves as members of a group. Group singing gave participants common ground despite different backgrounds, which allowed for greater empathy and understanding of others that lead to better singing. Instructors encouraged participants to become *"one voice"*, urging singers to be more aware of and connected to one another. Introverted participants noted how they were less shy at the end of the programs. While this could be associated with becoming accustomed to the workshop, the participants recognized that the skills and experiences learned in teamwork and individual achievement could be applied outside the workshop. Overall, this showed the relationship between confidence and sense of achievement, indicating a two-way exchange: with greater sense of achievement, participants' confidence grew.

Instructors' individual characteristics and relationships with participants were found to be a vital mechanism that drove many improvements in well-being. Instructors acted as catalysts for forming team relationships: an animated manner of speaking, dynamic movements, and full immersion into exercises had visible impacts on participants. The positive influence helped participants partake in exercises, leaving behind self-conscious thoughts and hesitant behavior. Instructors played the role of the regulator, ensuring an all-inclusive and friendly environment in the workshops that created conditions for socializing and put participants at ease.

3.5 Development of Evaluation Framework

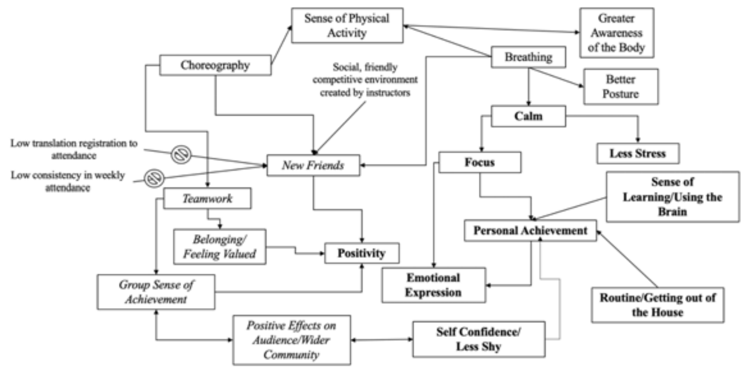
Based on the themes described in the previous sections 3.2 to 3.4 – physical, personal, and social benefits on well-being – we created an evaluation framework that conceptualizes group singing into the themes (Figure 1).

Figure 1: *Singing Evaluation Framework Developed by Categorizing and Analyzing Effects of Group Singing Activities on Holistic Health.*



The evaluation framework was used to develop a schematic map portraying interactions between themes and categories, along with underlying mechanisms (Figure 2). We found considerable overlap between components, further demonstrating the holistic relationship between group singing and health.

Figure 2. *Schematic diagram showing interwoven nature of the themes of physical, personal, and social impacts of Sing to Live, Live to Sing and GLUE Sings. Keywords in physical category are in regular print. Personal category keywords are in bold. Social category keywords are in italics. Smaller text shows phenomena that underlie these categories and keywords. Negative signs signal phenomena that decreased the degree to which the keyword impact was able to take place.*



Discussion

We found that group singing had physical, personal, and social impacts. Physical impacts included improvements in breathing, particularly for those with respiratory disorders. Better posture and awareness of the body through choreography and physical movements were also mentioned. In terms of personal impacts, group singing engendered a positive mood and greater self-confidence through relieving stress, enabling emotional expression, and empowering learning. Social impacts included meeting new people, feeling valued, and belonging to something. Instructors played a key role in the forming of relationships. We developed a conceptual framework for the relationship between group singing and health, which addresses the investigation of interactions amongst different effects [5].

Our framework consists of interlinking themes of physical, personal, and social health. The framework developed in this qualitative research is similar to the framework by Davies et al., which described the health outcomes of the wider concept of arts engagement with the outcomes of mental health, social health, and physical health for the individual and greater community [11]. This consistency strengthens the evidence base for the role of the arts in health. Our framework was tailored specifically for analyzing group singing, rather than being applied to the general arts. We used the framework to go a step further and to map the interlinking relationships between subthemes which was not included in the Davies framework. Given the holistic definition of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [18], our framework will provide a useful way to conceptualize the role of group singing in this holistic view of health. This framework can be a useful tool in quantitatively investigating the role of group singing for health and evaluating group singing programs and interventions.

Our observed physical benefits support current literature, with breathing-related activity being mostly confined to participants with respiratory disorders in older participants [2,3]. While effects of music on physical illness could not be observed in the younger music group, breathing exercises helped participants in both groups to relax and focus – a phenomenon reflected in current research [5]. In both groups, the main effects were observed in personal and social development. Musical activity provided a means of emotional relaxation and stress coping [5], serving as a channel for divulging insecurities, along with hope to overcome them. Younger participants were happy and proud of the song they created, taking ownership of the work they put into the project [5]. The composed song belonged in the hip-hop genre – thereby differing from traditional 'choir repertoire' –and the unique opportunity allowed this paper to add to the body of evidence supporting the potential mental well-being benefits of hip-hop [19]. The programs provided opportunities for individuals to interact with their communities, serving as emotional outlets that linked the personal and social benefits of art [1,4-9]. Both programs saw collective creation as an important aspect in socializing and bonding, which increased individual self-confidence [5]. The evaluations went further to explore how instructors helped to foster open, safe environments and the mechanisms through which effects come about.

This study had several strengths. First, the evaluation of two different group singing interventions with different populations enabled a more comprehensive investigation of the impacts of group singing interventions on participants. Second, the use of participant observation allowed researchers to examine patterns in themes that arose in the interviews and situate participant responses in their actions and relationships in workshops. Third, in-depth thematic analysis has enabled the unpicking of the impacts and their mechanisms, which strengthened the proposed conceptual framework. Limitations of this study included its short time frames, as research for each program lasted only 3 months, thus disallowing observation of longer-term effects of participation. Researchers were unable to attend two *Sing to Live, Live to Sing* workshops due to the sensitivity of some vulnerable participants' health issues. In-depth interviews were conducted with the leaders of both workshops and a participant to account for being unable to attend these groups. Finally, *GLUE Sings* participants were relatively homogeneous (majority 13 years old, females), introducing potential selection bias [20]. Some interviews were short or were interrupted since interviews took place right before or after workshops in the community centers for the convenience of participants. However, this enabled a broader range of participants to be interviewed.

Future research should further investigate the effects that stakeholders, program structure, and participant demographics have on program success. Mixed methodology using both qualitative and quantitative methods would provide both statistical strength and humanistic portrayals of the effects of group singing. Researcher collaboration would allow for longitudinal studies on one program over longer time periods. Continued use of the proposed framework would organize information to ensure that interconnected effects in group singing are being observed. Through these studies, researchers will be able to understand the benefits of group singing to foster programs optimized for a community and its needs.

Conclusion

This paper undertook a qualitative evaluation of two group singing programs and developed a conceptual framework for evaluations of such programs. We observed potential holistic benefits of group singing for health along the themes of physical, personal, and social impact. The framework helped to highlight the interlinked nature of benefits and mechanisms by which these benefits occurred. We recommend the use of this framework in future quantitative and qualitative evaluations of singing programs. With data organized in this manner, policymakers and public health practitioners can use this framework for groups and their interconnections to support proposals for implementing future group singing programs.

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Biographical Statements

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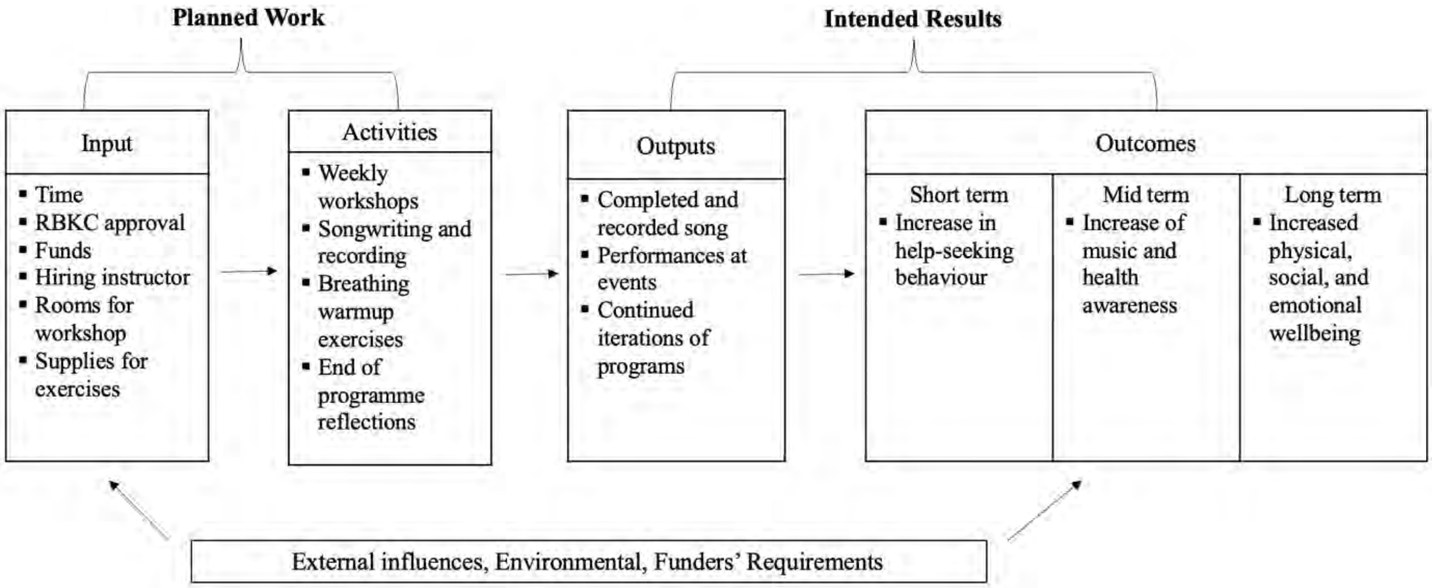
Appendices

Appendix 1: *Intervention Logic Model (Source: CDC. 2019)*



Appendix 2: Description of Songs Included at *Sing to Live, Live to Sing* Workshops

Song	Information
A Kiss to Build a Dream On	Composed by Bert Kalmar, Harry Ruby, and Oscar Hammerstein II, performed by Louis Armstrong
All of Me	Written and performed by John Legend with Toby Gad
Banaha	Congolese folksong
Blue Suede Shoes	Rock-and-roll standard written by Carl Perkins
By the Light of the Silvery Moon	Originally performed by Lillian Lorraine, written by Gus Edwards and Edward Madden
Cheek to Cheek	Originally performed by Fred Astaire, written by Irving Berlin
Don't Stop Me Now	Originally performed by Queen, written by Freddie Mercury
Dream a Little Dream of Me	Music by Fabian Andre and Wilbur Schwandt and lyrics by Gus Kahn, originally performed by Ozzie Nelson
Fly Me to the Moon	Jazz standard written by Bart Howard
Gracias a la vida (Thanks for life)	Composed and first performed by Chilean musician Violeta Parra
Heart of Glass	Originally performed by Blondie, written by Debbie Harry and Chris Stein
Hey Jude	Originally performed by The Beatles, written by John Lennon & McCartney
Hit the Road Jack	Written by Percy Mayfield, made famous by Ray Charles

Imagine	Performed by John Lennon, written by John Lennon and Yoko Ono
Imela (Thank You)	Spiritual song in Igbo language
Lean on Me	Written and performed by Bill Withers
Let's Dance	Originally performed and written by David Bowie
Mamma Mia	Originally performed by ABBA, written by Benny Andersson, Björn Ulvaeus, and Stig Anderson
Mother I Feel	Written and performed by Windsong Dianne Martin
Only You	Performed by Yazoo, written by Vince Clarke
Panis Angelicus	Written by Cesar Franck
People Get Ready/One Love	Performed by Bob Marley and The Wailers, written by Bob Marley and Curtis Mayfield
Praise You (I Wanna)	Traditional Spiritual
Pricetag	Performed by Jessie J and B.o.B., written by Jessie J, Dr. Jeffries, Claude Kelly, and B.o.B.
Proud Mary	Written by John Fogerty, performed by Creedence Clearwater Revival, and Ike and Tiner Turner
Purple Rain	Originally performed and written by Prince
Seven Generations	Traditional song taught by ear
Sitting on the Dock of the Bay	Performed by Otis Redding, written by Otis Redding and Steve Cropper
Siyahamba	Hymn written by Andries van Tonder
Stand By Me	Originally performed by Ben E. King, written by King, Jerry Leiber, and Mike Stoller
Stay with Me	Originally performed by Sam Smith, Written by Sam Smith, James Napier, William Phillips, Tom Petty, and Jeff Lynne
Summertime	Jazz standard composed by George Gershwin
Sunrise, Sunset	Written by Jerry Bock and Sheldon Harnick from Fiddler on the Roof
Super Trooper	Performed by ABBA, written by Benny Anderson and Björn Ulvaeus
Tainted Love	Composed by Ed Cobb
The Elements Song	Written by Tom Lehrer
This is Home	Traditional song taught by ear
Three Little Birds	Written and performed by Bob Marley
Wonderful World	Originally performed by Louis Armstrong, written by Bob Thiele (as George Douglas) and George David Weiss
Yellow	Written and produced by Coldplay

Appendix 3: *GLUE Sings lyrics written by younger subjects*

I am humble, I am strong
I can do magic all day long
I'm not frightened of the world
Believe in myself – now you've been told
I'll make sure I go to school
And I'll make sure I stand up tall

All people have dreams and goals,
But sometimes they can leave holes
Really hurt our souls
And they can make us feel likes moles
Don't let anyone take your education
You can do it for your nation
We are all one big team
And trust me when I tell you this is not a dream

I want to be strong
I want to learn
All this youth business can burn
So can you hear me now? (hear me now)
Will you hear me out? (hear me out)

Strength and belief is all that you need
As we need to be strong and believe to achieve
To get our goals we use brain power
So we can fly high as high as a tower
Shine like a star show off your talent
But also be humble and keep your balance
Don't be afraid of what's to come
You'll make it there and it will be fun
Strength is the key to achieving your dreams
Don't be silly no need to mean
Be a butterfly not a caterpillar
I'm not being funny we need to be realer

Less bullies more education
Knowledge could be your salvation
We all have powerful goals
We're not here to talk about pretty dolls

I want to be strong
I want to learn
All this youth business can burn
So can you hear me now? (hear me now)
Will you hear me out? (hear me out)

You can be strong in your body but not in your mind
You wonder why you're always left behind
You need to aim high to be first in line
You need to be quick because we don't have time

I want to be strong
I want to learn
All this youth business can burn
So can you hear me now? (hear me now)
Will you hear me out? (hear me out)

Full-Length Article

The effect of music mat exercises on device-measured sedentary time and physical activity among 4–6-year-old Finnish children and their parents: *A pilot study*

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Abstract

Exercises on a music mat were developed to promote physical activity (PA) among 4- to 6-year-old Finnish children and their parents, and to decrease sedentary behavior (SB) in the home environment. Altogether, 15 families participated in an eight-week exercise intervention using a music mat. SB and PA were assessed with a tri-axial hip-worn accelerometer, alongside exercise diaries and questionnaires. The statistical methods employed a linear mixed-effects model design and questionnaires were analyzed using thematic analysis. Regarding children (n = 14) and mothers (n = 14), any statistically significant differences in the primary outcomes over time were not found. Among fathers (n = 8), in turn, the reduction of SB was statistically significant (p = 0.031). Most of the children and all of the parents used the music mat less than instructed. One-third of the children who used the music mat regularly as instructed increased their moderate-to-vigorous PA and Total PA and decreased their SB. The shared activity of children and parents was reported as being particularly important for families. In conclusion, the music mat exercises in the home environment may promote PA or reduce SB among those children whose parents were motivated to exercise together with the child regularly. The exercises might be a good addition to weekly PA and help break long sedentary bouts.

Keywords: ***family, music-based exercises, accelerometer, sedentary behavior, physical activity***

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Introduction

Both regular physical activity (PA) and low levels of sedentary behavior (SB) are known to mitigate risks for cardiometabolic health indicators and to promote life-long health behavior [1, 2]. The current PA guidelines recommend at least 180 minutes of activity for children at any intensity spread throughout the day [3]. It is recommended that adults perform at least 150 to 300 minutes of moderate-to-vigorous PA and muscle-strengthening and balance training at least twice a week [4]. Excessive sitting should also be avoided [4].

SB, such as excessive sitting and screen time, is one of the significant concerns for children's healthy growth and development all over the Western world. Increased screen time among children is associated with being overweight and/or obese [5], but a prospective association between SB and cardiometabolic risk is partly unclear [6]. Furthermore, positive changes in PA are associated with physical, psychological, social, and cognitive health indicators [7], and the amount of both light PA (LPA) and moderate-to-vigorous PA (MVPA) are related to cardiometabolic biomarkers [6, 7]. Moreover, all patterns of activity, for example, sporadic and continuous bouts, provide health benefits [7]. However, interventions for increasing PA have had only small changes in children's daily PA levels [8], and behavior changes might need incentives for encouraging PA behavior [9].

Benefits of early shared music activities

Research on early shared music activities in the home between children and their parents show benefits for children in subsequent years. Music has been proposed to promote behavioral change through increased exercise adherence and participation [10]. In addition, a growing number of studies show that informal music activities, such as singing, playing an instrument, and musical play in the home environment, are positively associated with children's health [11] and PA [12]. Including movement-to-music in PA programs and structured exercises has been found to increase the amount and intensity of PA [13, 14]. Children have also been found to prefer movement- and playing-based activities [12]. Among adults, motivational music has been found to enhance affect, reduce ratings of perceived exertion, improve energy efficiency, and lead to increased work output [15, 16].

The effects of music-based activities on device-measured PA and SB are not well understood. A recent pilot study found

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that children and mothers who exercised at home together using the movement-to-music video accumulated less SB and more light PA (LPA) and moderate-to-vigorous PA (MVPA) than children and mothers who did not use the video [17]. However, a subsequent randomized controlled trial (RCT) indicated no significant differences in SB or PA of children and mothers between intervention and control groups during follow-up [18]. Moreover, a recent meta-analysis showed that active video games could be useful for decreasing SB and increasing PA in field-based settings when compared to sedentary alternatives, such as resting, TV viewing, or inactive video games [19]. However, when active video games are compared to children's typical PA, the findings are conflicting [20]. Furthermore, free-play activity in and of itself has not been found to stimulate MVPA among children [21]. Among sedentary adults, aerobic music-based exercise has been found to be a way to promote participants' PA and increase their intention to remain physically active in an 11-week randomized study [22].

Maloney and colleagues found that children who used the Dance Dance Revolution (DDR) game in their 28-week intervention increased their vigorous PA (VPA), while there were no changes in the control group. Children's sedentary screen time also decreased among those who used the DDR game but increased among those who did not have the game [23]. However, Maloney and colleagues studied only within-group differences, and they did not have any comparisons between the groups. On the contrary, Baranowski and colleagues (20) did not find any evidence that children's active video gaming would result in more PA than inactive video gaming did in the home environment. Gao, Zhang, and Stodden concluded that traditional aerobic dance should not be replaced with interactive video games since the children accumulated more MVPA in aerobic dance than when playing DDR [24].

Studying these effects is challenging, because the combination of PA, SB, and music-based activities may be a complex mixture in children's daycare and leisure time, and strongly influenced by their parents and other adults, such as caregivers. Parent-caregiver and parent-child communication and cooperation have been found to be valuable in promoting PA among children [25, 26]. Mothers' and fathers' PA and TV viewing have been found to be associated with these behaviors in their children [27].

A music mat as an instrument of physical exercise

The music mat has been developed by Taction Enterprises (USA). It was originally developed for playing music and creating new musical environments using hands, legs, or other body parts. The music mat is a 1.5 m x 1.5 m mat with twelve capacitive sensors placed under it and connected to a tablet via a USB port. The tablet is connected to a Bluetooth speaker, and when one touches a sensor, the software develops a pre-set sound. Multiple sensors can be touched at the same time, which offers the possibility to create rhythm, melody, and harmony. The difference between dance and music mats is the way they are used. With a dance mat, players listen to music and follow instructions showed on the screen. With the music mat, players select sounds on the screen and create music and movements on their own.

To our knowledge, no prior study has tested the effects of physical exercises on accelerometer-measured PA and SB when using a music mat. In this study, physical exercises on a music mat were developed to promote PA and decrease the SB of families in their home environment. We aimed at assessing whether movements and exercises on the music mat influence accelerometer-based total daily PA and SB among children, their mothers, and fathers. We were also interested in gathering the experiences of the participants' while they used the music mat. We hypothesized that exercises on the music mat would account for more PA and less SB than typical daily activities among children and their parents. Our specific research questions are as follows: (1) What are the effects of music mat exercises on sedentary time and physical activity among children and their parents? (2) What are children's and parents' experiences when using the music mat?

Materials and methods

Participants and study design

Fifteen families were recruited from the area of Jyväskylä, Finland, via early childhood education between September 2017 and August 2018. The families were invited to a briefing via an information e-mail, and they were given oral and written information about the study, and a chance to test the music mat. Families were eligible to participate if their child was between the ages of 4 and 6, the child and at least one parent had normal vision and hearing with or without glasses or a hearing aid, room enough for the music mat at home, and the ability to perform PA and use the music mat and accelerometer as instructed. All parents provided written consent for themselves and on behalf of their child. The study was approved by the Ethics Committee of the University of Jyväskylä (Jyväskylä, Finland).

The primary outcomes of the study were a mean daily proportion of SB and PA, which were assessed by the accelerometer, and further examined via questionnaires and exercise diaries.

Accelerometer measurements

The hip-worn accelerometer (Hookie AM30, Traxmeet Ltd, Espoo, Finland) used in the study collected and stored the tri-axial acceleration signal in raw mode [28]. Mean amplitude deviation (MAD) values (6-second epochs) were converted to METs (metabolic equivalent, 3.5 ml/kg/min of oxygen consumption), and intensity was calculated as epoch-wise MET values [28]. Due to the sporadic movement of children, 6-second epochs were used in the analysis. Among adults, the one-minute moving average was used. The assessment of SB was based on the angle for posture estimation [29]. Lying and sitting down (<1.5 MET) were combined to SB. Standing (SS < 1.5 MET) and light PA (LPA 1.5–2.9 MET) were analyzed separately [30]. MVPA covered moderate PA (MPA 3.0–5.9 MET) and vigorous PA (VPA ≥ 6.0 MET) [30]. With the hip-worn accelerometer, both stationary and sedentary behaviors and physical activity can be identified reliably [29], and it is a valid measurement tool among adults [28, 29], and a feasible instrument among children as well [17].

For measurements, participants were instructed to use the accelerometers during waking hours daily for weeks 1, 2, and 9, for seven consecutive days at a time. The accelerometer data (at least four days per week and at minimum 10 hours/day) were used in the analysis if there was at least one acceptable measurement week for the accelerometer data.

Questionnaires and exercise diaries

The information on parents' background included data on age, height, and weight (self-reported), marital status, number of children, socioeconomic status, and perceived health (measured via a visual analog scale, VAS). The information on children's background included data on age, height, and weight (measured using standard wall mounted stature meter and the TANITA BC-601 device) gender, daycare status, and participation of a special music education group in daycare.

We also collected free comments and perceptions with open-ended questions from children and parents about the use of the music mat. Moreover, participants completed an exercise diary during intervention from baseline to the end of the study. The diaries included data (day and duration) on completed exercises performed on the music mat and other physical activity.

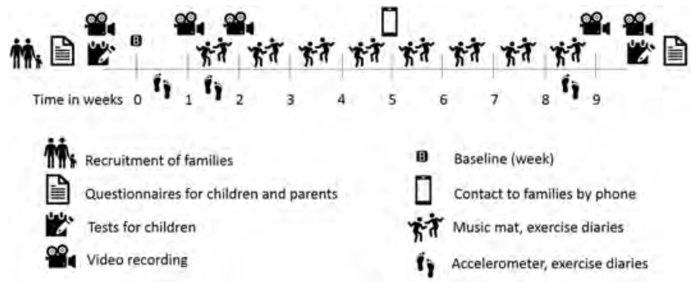
Intervention and data collection

After recruitment, participants gave their consent for participation, and then they completed the baseline questionnaire for background information, one of the parents together with the child.

Within the nine weeks (Figure 1), the first week was used as a reference for the accelerometer measurements, indicating participants' typical PA and SB. The music mats were delivered to the families at the beginning of the second week. Children and their parents were instructed to move on the mat at least every other day for at least 15 minutes from the beginning of week 2 (the first intervention week) to the end of week 9 (the last intervention week). Both movement-based and music-based exercises and play instructions were given to the families. They were encouraged to move in a variety of ways on the mat by, for example, walking, jumping, or break-dancing. By moving on the mat, the participants (one or more at a time) were able to play familiar songs or create a new musical environment. Families were also contacted in the middle of the intervention period so that they could ask for more exercises. Furthermore, parents were instructed to encourage their children and exercise with them.

After the intervention period, the participants completed a questionnaire with open-ended questions about their experiences.

Figure 1. *The sequence of the study phases*



Statistical analysis

Baseline characteristics and outcomes were reported as means and standard deviations and as frequencies and percentages. The proportions of measurement time in SB, SS, LPA, and MVPA were analyzed using a linear mixed-effects model (LME) with time in days. Due to a small number of participants, the restricted maximum likelihood (REML) option was used as a method for the standard errors of the fixed effects [31]. The unstructured covariance structure was used as a covariance type for repeated measurements [32]. A single day of outcome variable was removed as an outlier if its standardized values (z-score) were less than -3.30 or higher than 3.30. To evaluate the association between children's and parents' SB and PA, the Pearson correlation coefficient was calculated using variables based on a one-minute exponential moving average. Due to the small number of participants, exact logistic regression was used to examine the association between background variables (age, height, weight, number of siblings, engaging in preschool, music or sports hobbies, parents' employment, education, and perceived health) and the change in SB, SS, or PA. Odds ratios (ORs) with p-values were reported.

The number of observations was fixed to 15 families, as the purpose of the study was to pilot the practical implementation possibilities. Thus, the sample size calculation was not done for this study. As sensitivity analyses, the LME model was used for those children who used the music mat as instructed. For all analyses, the p-value of <0.05 was considered statistically significant. Stata Statistical Software version 15.1 was used to perform exact logistic regression. All other analyses were performed with IBM SPSS Statistics 24.0.

Qualitative thematic analysis

The thematic analysis of the questionnaire was based on six phases by Clarke and Braun [33]. The data from open-ended questions were collected for familiarization and coding. An inductive and semantic approach was used to search for and determine the themes as well as to analyze the content of the data. The themes were checked and reflected on with the original answers, coded extracts, and the content of different themes. Additional refinements and merging of the themes were implemented to create and name suitable entities. Participants' original answers were translated into English, and numerous quotations were presented along with the results of thematic analysis.

Results

Demographic characteristics

Fifteen families were recruited and participated in the study. However, one of them was excluded because the child fell ill. Thus, 14 children, 14 mothers, and the 8 participating fathers were included. All of them participated until the end of the intervention. The demographic characteristics of the participating children, mothers, and fathers are presented in Table 1.

Table 1. *Characteristics of the participants (n = number of participants, SD = standard deviation)*

	Children (*n* = 14) mean (SD) / %	**Mothers (*n* = 14)** mean (SD) / %	**Fathers (*n* = 8)** mean (SD) / %
Age (at the beginning of the measurements)	5.7 (0.7)	34.7 (3.6)	36.0 (3.9)
Height (cm)	114.4 (7.7)	166.1 (4.7)	178.8 (4.6)
Weight (kg)	20.6 (3.4)	68.1 (12.4)	79.4 (8.9)
BMI (based on measured weight)	21.3* (2.7)	24.7 (4.5)	24.8 (2.7)
Gender			
girl	71.4%		
boy	28.6%		
Childcare			
preschool	35.7%		
daycare	42.9%		
children's club	21.4%		
Having a special music education at childcare	50.0%		
Marital status			
married or cohabiting		85.7%	87.5%
divorced or unmarried		14.3%	12.5%
Education			
university degree		71.4%	75.0%
other qualification		28.6%	25.0%
Employment			
full- or part-time work		64.3%	62.5%
maternity, parental, or childcare leave		14.3%	0.0%
unemployed or laid off		7.1%	0.0%
other		14.3%	37.5%
Number of children		2.3 (0.9)	2.3 (0.5)
Perceived health		66.0 (21.5)	69.5 (14.8)

* Transmitted to adult scale

Children used the music mat, on average, for 219 minutes (min 10, max 505; 19 minutes per session) during the intervention period. The child who used the music mat for 10 minutes only got frightened by one sound and refused to try the mat a second time. The corresponding values for mothers were 57 minutes (min 0, max 220; 14 min/session), and for fathers 21 minutes (min 0, max 95; 15 min/session). Altogether, 5 of 14 children used the music mat as instructed throughout the intervention. However, 11 of 14 children performed at least one exercise session during the last intervention week. All the parents used the music mat less than instructed. Six of 14 mothers and 5 of 8 fathers did not use the music mat at all.

Accelerometer measurements

All participants used the accelerometer during weeks 1, 2, and 9, with a weekly average of acceptable measurements being 5.8 days per week among children and 6.2 days per week among mothers and fathers, separately. Measurement time (accelerometer wear time) covered around 12.6 hours per day among children, 13.9 h/d among mothers, and 14.9 h/d among fathers. The use of the accelerometer and the weekly average of measurements are presented in the supplementary material (Table S1, Table S2).

Regarding children and mothers, no statistically significant differences over time were found (Table 2). Instead, among fathers, the reduction of the proportion of SB was statistically significant (p = 0.031). Figure 2 illustrates scatter plots for SB and Total PA and changes over time in SB and Total PA among children and their parents. In addition, the association of SB and PA between children and parents was negligible (r = -0.15 to 0.27).

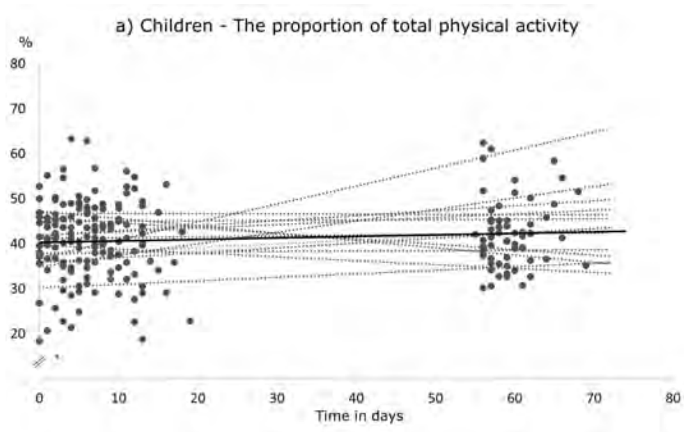
A sensitivity analysis for those children who used the music mat as instructed (n = 5) showed a non-significant reduction in SB (unstandardized coefficient -0.03; 95% confidence interval (CI) -0.18, 0.13), SS (-0.17; -0.42, 0.07), and LPA (-0.01; -0.11, 0.08), and an increase in MVPA (0.10; -0.23, 0.44), and Total PA (0.06; -0.24, 0.35).

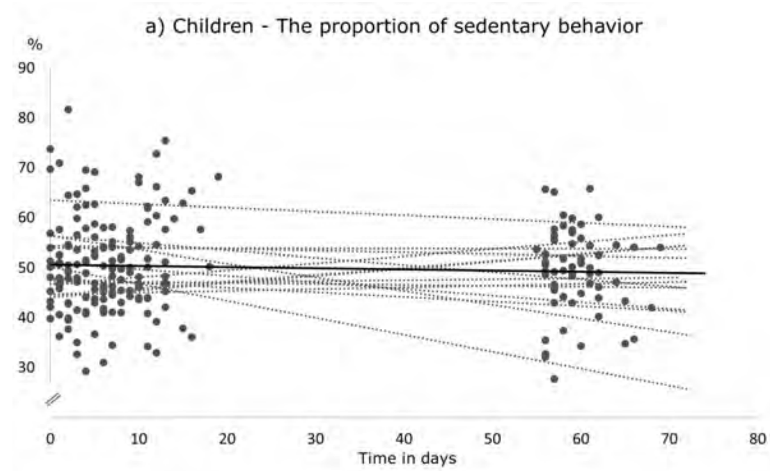
Table 2. *Change within the group of children, mothers, and fathers in sedentary behavior and physical activity over time as a proportion of measurement time (unstandardized coefficients with their 95% CI) and p-value from linear mixed-effects models*

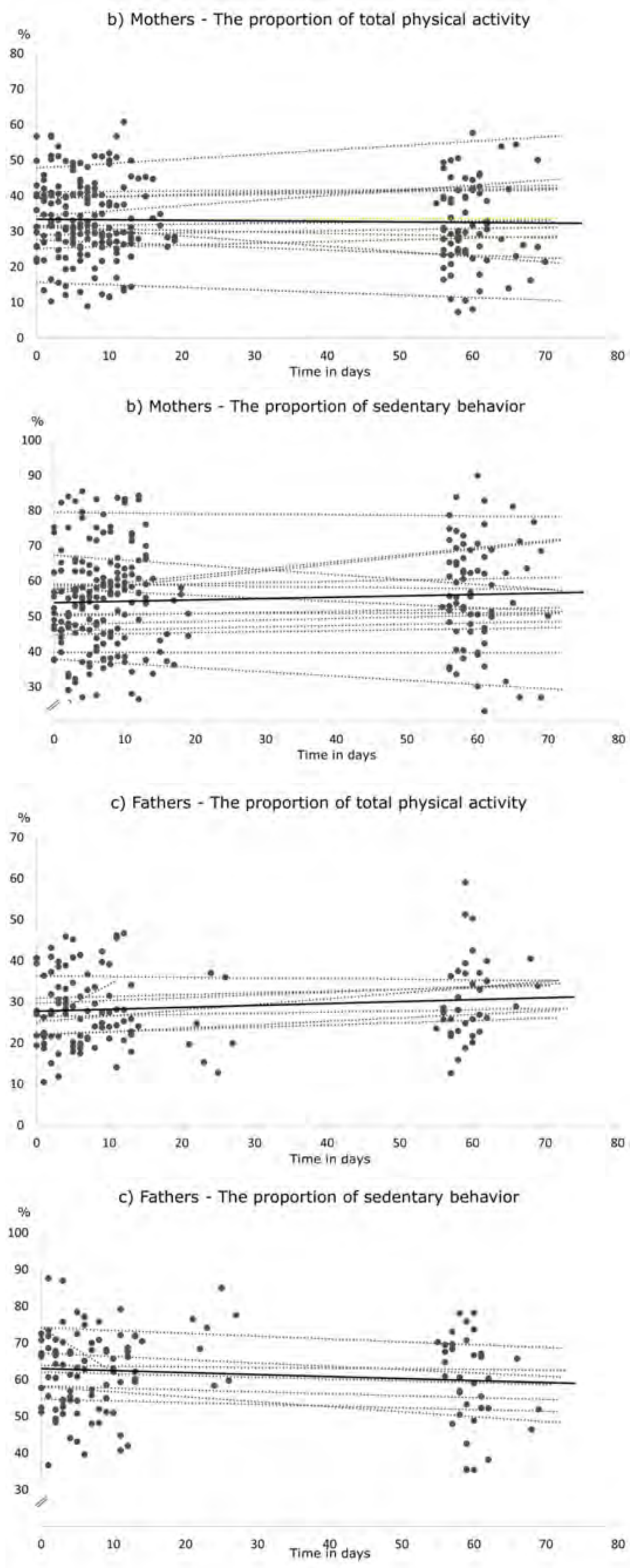
	Children* (n = 14) unstandardized coefficient (95% CI)	p-value	Mothers* (n = 14) unstandardized coefficient (95% CI)	p-value	Fathers* (n = 8) unstandardized coefficient (95% CI)	p-value
Sedentary behavior	0.02 (-0.04, 0.07)	0.49	0.02 (-0.04, 0.08)	0.47	-0.06 (-0.11, -0.01)	**0.031**
Standing	-0.08(-0.16, 0.01)	0.080	-0.01 (-0.05, 0.03)	0.59	0.03 (-0.01, 0.06)	0.10
Light physical activity (PA)	0.007 (-0.02, 0.04)	0.62	-0.01 (-0.06, 0.04)	0.59	0.03 (-0.03, 0.09)	0.23
Moderate-to-vigorous PA	0.0003 (-0.06, 0.05)	0.99	-0.07 (-0.19, 0.04)	0.19	-0.24 (-0.74, 0.26)	0.27
Total-PA	0.006 (-0.05, 0.06)	0.81	-0.02 (-0.06, 0.03)	0.45	-0.35 (-1.57, 0.88)	0.38

* Measurements at least 10 h/d, at least 4 d/w

Figure 2. *Scatter plots, changes over time, and trend lines for the proportion of (a) children's, (b) mothers', and (c) fathers' sedentary behavior and total physical activity.*







Scatter plots illustrate every accepted individual measurement value for each participant during weeks 1, 2, and 9. Dotted lines present individual changes over time, and a solid black line indicates an average fitted trajectory for all participants.

By using exact logistic regression for additional analysis, age (OR = 16.1, p = 0.024), height (OR = 1.51, p = 0.023), and attending preschool (OR = 20.3, p = 0.023) showed a higher probability of increasing children's SS (n = 9). Regarding mothers (n = 11), older mothers had a higher probability of increasing Total-PA (OR = 1.92, p = 0.043). Further, weight decreased the odds of increasing LPA (OR = 0.81, p = 0.030) and Total-PA (OR = 0.85, p = 0.052). Among fathers (n = 6), no statistically significant association was found regarding their background variables.

Children's and parents' experiences

In the qualitative thematic analysis, three main themes that emerged from the data analysis process were found among both children and mothers. The quotations provide examples of key themes and ideas. Furthermore, an asterisk was added to the end of the child's and mother's comment if their Total PA increased and SB decreased.

Children's perceptions, interests, and social aspects of exercise

The first theme among the children was related to their positive, negative, and mixed or neutral perceptions. Their perceptions were mostly positive regardless of the amount of their SB, SS, or PA. Comments from children were almost entirely short and reflected their feelings:

> "It was fun." *
> "It was nice to use the mat." *
> "Just lovely."
> "Sometimes it was nice to try and sometimes not."
> "I didn't like the music mat." *

The second theme was interest in the use of the music mat that included exercise-related comments and descriptions of detailed activities. The comments told short stories about something that was just done, or the use of the music mat itself, for example:

> "Recording your own voices was the funniest thing." *
> "The music mat was too small. It wasn't nice." *
> "The music mat was really dull. It was hard to come up with different movements." *

However, some of the comments also indicated external interests related to the use of the mat. More specifically, external interests included having a prize (stickers for the diary) or doing something that the child could not do in everyday life:

> "The stickers [used in the diary] were nice."
> "It was nice to play on a tablet."

Additionally, children explained why they did not move on the music mat and that they might have had some other interests during the summer season:

> "It's also nice to take it easy." *
> "It was just hot now and there was a lot to do."

The third theme was related to social aspects. Most of the exercises were instructed to be done together with parents, siblings, or friends. The children who exercised together with someone else described their senses:

> "It was nice to do it with mom and dad." *
>
> "It was more fun to use the music mat with someone than alone." *

The music mat as a part of everyday life, motivation, and changes in physical activity

Mothers shared parental perceptions on the use of the music mat. No fathers described their perceptions. The first theme found from the data was related to the use of the music mat as a part of everyday life. Two mothers who used the music mat at least sometimes and one mother who did not use the mat at all described how challenges arose for families when parents' work, children's hobbies, and other activities of daily living took their time. They also explained how the music mat was used or why it was not used:

> "Our everyday life with its many hobbies, friend patterns, husband's long working days, and my own strenuous work is so hectic that our contribution to using or resembling the mat has been minimal. But on the other hand, the children have not longed for it either, so that they would have wanted to use it often."
>
> "We found it challenging to fit using the mat into our daily lives. Coming home from kindergarten around 5 pm for dining, outdoor activities, and play (this point was the only thing that could have been replaced), then the evening doings. We all found outdoor activities to be our preferred option. On weekends, exercise with the mat was easier."
>
> "Our everyday life is full of hustle and bustle on summer evenings, and we have been mostly outside." *

Moreover, some mothers had opposite opinions about the user interface. For some of them, the music mat and its' software were hard to use, while some mothers find it easy:

> "The music mat takes up a lot of space and is relatively time-consuming to use."
>
> "A little difficult to use. Too many things on the tablet that work differently than they do the other [on our own tablet]. Too many wires."
>
> "Great idea ! Easy for a child to learn to use." *

The second theme was related to social aspects, mothers' expectations, and motivation. Mothers who sometimes used the mat together with the child, found the connection the mat creates between parents and the child to be very positive. However, some mothers thought that the use of the mat would have been only for the child. Additionally, they stressed the influence of their behavior on the child, and they also wrote that their own interests would have been different from the child's:

> "--- When we used it [together], we did have a child-friendly time."
>
> "If the mat were easier to put on, the child could use it more. Our 5-year-old didn't always know how to put it on."
>
> "It didn't work in our family…..I think the use of the mat would have started with the child himself, that it would have been a child's thing, but it didn't go that way. Personally, I wasn't motivated to move on the mat. If I had been, surely the child would have used it more too." *
>
> "The different sounds didn't inspire me to move. I was on the music mat just because the kid would be on it too."
>
> "Rhythmic exercise would have motivated me, but the child wanted a different kind of music [than I did]."

As a part of motivation, mothers also spoke about how the visual look of the music mat could promote the use of the mat. They noted that colors, lights, and vibrations or the use of different themes could make the mat more inspiring for children.

> "Nice experiment. I believe that the visual look, such as colors and somehow in line with some theme, children might get even more excited and come up with stuff and games on the mat themselves."
>
> "The mat may not be interesting enough for a child over a longer time. There should be colors, lights, vibrations, etc."

The third theme explored the amount of physical activity and changes in it during the intervention. Mothers' thought that the music mat did not increase their or their child's physical activity overall:

> "Our child was interested in the music mat...but we felt that the mat did not make our child or us move more."
>
> "The mat was used very little; the child was interested in outdoor activities due to the beautiful warm weather."
>
> "The mat was an excellent addition to exercise in everyday life. Still, I didn't find that increased my exercise or the child's exercise, either."

Discussion

The present study aimed to investigate the effects of the music mat exercises on device-measured sedentary behavior (SB), standing (SS), light physical activity (LPA), moderate-to-vigorous physical activity (MVPA), and light-to-vigorous physical activity (Total PA) of the children and their parents. The study also accounted for the association between children and their parents in these variables. Further, the study aimed to gather participants' experiences about the use of the music mat.

As a summary, no statistically significant changes over time were found except for the reduction in fathers' SB. However, none of the parents used the music mat as much as instructed. Moreover, the association in all outcomes between the children and their parents was negligible. In the qualitative analysis, children's experiences were associated with their perceptions, interests, and the social aspects of exercise. The main themes among mothers were everyday life, motivation, and physical activity.

Based on the statistics of Eurostat, on average, 45.6% of the Finnish adult population (aged 25–54 years) have a high educational level [34]. In this study, almost three of four parents had a university-level education representing well-educated Finnish families. Highly educated parents might be more aware of a healthier lifestyle. Thus, at the baseline, the average proportion of Total PA was higher than among the general population of Finnish adults representing the same age group (30–39 years) and sex [35].

Among the children, the proportions of SB and PA at baseline were, on average, at the same level as in an earlier study regarding 5- to 6-year-olds using music-based activities [18]. During the baseline week, children spent an average of 50% (6.3 hours per day) of their waking time sedentary, which is approximately one hour more than reported in Finland's Report Card 2016 [36]. However, children spent an average of 41% (5.2 hours per day, including 2.4 hours per day in MVPA) of their waking time being physically active, which is considerably more than the most recent PA guidelines recommend for children [3, 4].

The families were instructed to use the music mat for at least 15 minutes every other day, and they had both oral and written guidance and exercises for it. However, the intervention showed how difficult it might be to motivate participants to exercise as instructed. Parents seemed to be passive in using the music mat, and based on the thematic analysis, mothers felt that it was challenging to include the use of the mat in daily routines. Differences in technical skills may have also influenced the attitudes of the families. Moreover, some families may have found it challenging to find a permanent place for the music mat. If you always need to pick up the mat and put it away after use, it seems likely that the use of the mat stops after the initial enthusiasm.

We found that one-third of the children, but none of the parents, used the music mat as much as instructed. Baranowski and colleagues reported that active video games, including the dance mat games, were not used routinely enough to increase the PA levels of children at home [20]. However, children in the that study were older than the children in the present study. In the present study, families were contacted at least four times face-to-face and additionally by text messages or phone calls during the study period. If there had been more contact, the training might have been more active.

Encouraging children and their parents to be more active and to maintain motivation is a huge challenge for all interventions conducted at home instead of daycare, guided exercise interventions, or laboratory conditions. Additionally, the progressively increasing challenge in music and exercises delivered via daycare, YouTube, or social media, might motivate children and their parents to be more active. However, four-fifths of the children used the music mat during the last intervention week, indicating that there was at least some interest in using it. Based on the thematic analysis, children's perceptions were mostly positive, even if some of them indicated external interests instead of just having fun. Furthermore, the participation rate in this study was much higher compared to the study using a movement-to-music video program, in which only 10% of participants used the videos during the last intervention week [18].

Parental and peer participation has been shown to affect children's participation in dance exergames [37]. In this study, both the children and mothers found positive meaning in doing things together. Exercises which were done together with children and parents were felt to increase the quality time of families. This would be an important point for a child's healthy growth and development. However, some mothers seemed to be disappointed that the child needed parents' help to use the mat.

Among children, a non-significant increase in SB and PA, along with a decrease in standing over the intervention period, was found. These results were similar using either a six-second data or a one-minute moving average for analyses. Based on the thematic analysis, the amount of or changes in children's SB, SS, or PA could not be explained with their positive, negative, or mixed and neutral perceptions. However, it can be seen from qualitative data that children who named external interests, did not increase their PA or decrease their SB. This is in line with Owen and colleagues (2014), who found that external regulation, such as acting to obtain a reward, had a negative association with PA, while the association was positive if the motivation to exercise was intrinsic [38]. However, even if our study group was tiny, we assume that the music mat exercises may provide a tool to decrease SB and increase PA for children who are interested in the creation of music or sounds with the mat and are committed to physical exercises.

Among those children who used the music mat as instructed (sensitivity analysis), there was a non-significant reduction in SB and an increase in MVPA and Total-PA. Furthermore, older or taller children or those who attented preschool were more likely to increase their SS than were younger, shorter, or those who did not attend preschool. These results are partly in line with Gao and colleagues [19], who concluded that, for children, exergames could be a good alternative for SB alongside traditional PA and sports.

Wadsworth and colleagues [21] concluded that free-play activity did not stimulate MVPA among 4-year-olds, but specific task structures did. In our experience, the music mat offers much more freedom to choose movements and gives possibilities to create a musical world when moving on the mat than a dance mat does. However, some of the children's performances on the music mat were calm, and those were recorded with the accelerometer as SB, SS, or LPA. On the other hand, dance-based exergames offer precise levels to challenge oneself when an earlier stage turns out to be too easy.

Among the mothers, the changes were small and non-significant, and the direction of the changes was unhealthy. However, a high proportion of PA and low SB at the baseline may make it challenging to increase PA and reduce SB over the intervention. This is in line with Madison and colleagues [22], who concluded that music-based exercises could be recommended to promote PA among sedentary individuals. Furthermore, in this study, older mothers were more likely to increase their Total PA than younger mothers. Those who were heavier were also less likely to increase their LPA and Total PA. Regarding fathers, the statistically significant reduction in SB may be due to the high level at baseline. Further, several studies have found associations between children's and parents' SB and PA [25, 27], but in the current study, we found mostly negligible relationships.

Mothers discussed their own, and their child's motivation as well: they wrote that if they were not motivated to move on the mat, nor were their children. Even if the children would have been interested in the music mat, mothers felt that moving on the mat did not change their own or their child's PA. Young children's desire or motivation may not be enough for the long term, and the encouragement and involvement of parents are necessary for a child's behavioral change.

Strengths and limitations

The major strength of the study is the use of a valid [28, 29] and feasible [17] hip-worn tri-axial accelerometer. Although the number of acceptable measurements decreased during the intervention period, the weekly average (measurement days per week) and daily measurement time remained at a high level both among children and parents, which increases the reliability of the measured SB and PA. Another strength is the combination of collecting, reporting, and discussing children's and parents' perceptions together with accelerometer-measured data.

There were several limitations in this study that may have influenced the findings. The families were recruited via one childcare center, and participation for the study was voluntary. These facts may have affected the background characteristics of the sample: the educational status and PA levels of most families were higher than the population average in Finland. Additionally, the number of recruited families was limited to 15, which indicates together with sample characteristics that the results are not representative of a larger population.

Conclusion

The use of the music mat in the home environment was not effective in increasing PA but may have promoted PA or reduced SB among children whose parents were motivated to exercise together with the child regularly. At the very least, mat exercises might be a good addition to weekly PA and help break long sedentary bouts. Both children and mothers emphasized the shared activity of children and parents as particularly important for the families. For future studies, it would be important to evaluate (1) how to identify the subgroup which is interested in this type of music-based PA exercises and (2) how to create an exercise program with a progressive, growing challenge so that the use of the music mat would be more attractive for a larger population and encourage children and their parents to use the mat and to potentially become more active.

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Full-Length Article

Music listening to decrease intensity of agitated behaviour after severe acquired brain injury: *An experimental multi-case study*

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Abstract

Agitated behavior following a traumatic brain injury is frequent, placing patients and staff at risk of injury. Such behaviors decrease rehabilitation outcomes. This case study explores staff-administered listening to preferred music as an intervention to reduce agitated behavior during sub-acute rehabilitation. The study included seven patients (6♂/1♀, aged 21-74 years) with agitated behaviour and suffering from severe acquired brain injury of different aetiologies. The intervention included 15 minutes of preferred music from a customized playlist created in collaboration between a relative, a music therapist and the staff at the rehabilitation clinic. Agitated Behavior Scale (ABS)-scores, blood pressure and heart rate measurements were obtained pre and post interventions. Two tailed t-test and visual analyses were conducted. Results suggest that listening to personalized playlists of preferred music with a supportive intensity profile may reduce the intensity of agitated behavior following an acquired brain injury in the sub-acute phase. Furthermore, the music listening intervention may have contributed to reduced pulse. Due to the small sample size and few measurements, further research to support the hypothesis is recommended. However, since music listening is an easily administered low-cost intervention with no obvious side-effects, it can be considered as a supplement to usual treatment.

Keywords: *Acquired brain injury, neuro-rehabilitation, agitated behaviour, music therapy, non-pharmaceutical*

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Introduction

Agitated behavior following a traumatic brain injury (TBI) is a serious condition reported with varying incidence rates of 35-96% in the acute phase and 36-70% during the rehabilitation course [1-4]. However, agitated behavior may also be present in patients with acquired brain injury (ABI) of non-traumatic aetiology, e.g., cerebral vascular incidents or hypoxia [5, 6]. Agitated behavior is characterized by inattention, disinhibition, emotional lability, impulsivity, motor restlessness and aggression [3, 7, 8]. Agitated behavior has consequences for patient outcomes because it interferes with participation in rehabilitation initiatives [9, 10]. Furthermore, agitation is disruptive to the therapeutic environment at the neurobehavioral unit [11], it places patients and staff at an increased risk of injury [12] and requires a costly round-the-clock observation to maintain patient safety [13]. Typical interventions addressing agitated behavior involve behavioral strategies, including verbal guidance, environmental adjustments and physical restraint, along with the use of pharmacological agents, such as antipsychotics, analgesics and antidepressants [12]. Pharmacological agents are frequently used in the management of agitated behavior, but the evidence of the efficacy is insufficient, and some may even reduce the rate of recovery during the early post injury period [14-17]. Physical restraint should be minimized to respect patient autonomy [18] and it may also hinder the rehabilitation progress [11, 13]. Based on this, it is necessary to develop alternative interventions aimed at alleviating the condition [19] in order to support the effect of rehabilitation efforts, and to reduce the need for pharmacological agents [20].

The effect of music listening for people with ABI in the early stages of rehabilitation has been rexplored in a few studies [21-23]. Results showed that listening to preferred music had a positive effect on verbal memory and focused attention [22]. Further, listening to preferred music showed to reduce agitation and enhance orientation significantly in the Post Traumatic Amnesia phase following a TBI [24]. These results were supported by Park [25] who found that listening to preferred music, as compared to listening to relaxing classical music, had a significant effect in reducing

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physical and cognitive agitation in patients with severe traumatic brain injury. The three mentioned studies all illuminated the possible effect of listening to preferred music. In Baker and colleagues' study [24], the effect of listening to preferred recorded and live music was compared, finding no significant differences. The study conducted by Särkämö and colleagues [22], listening to preferred music was compared to listening to recorded books and no listening material, finding that only music listening produced a significant effect. The study by Park [25] compared the effect of relaxing classical music and preferred music, finding that only preferred music produced an effect.

The time frame of music listening differs within the studies. In Baker [24], the participants were exposed to preferred live and taped music (plus no intervention) twice a day for six consecutive days.

In Särkämö et al. [22], the participants listened to the material (music, book, no material) daily for two months. In Park et al [26], the effect of one hour of music listening was measured pre and post the intervention using a cross-over design to compare the effect of relaxing classical music vs. preferred music over three consecutive days, with day two as a wash-out period.

In summary the results from these studies suggest, that listening to preferred music (recorded or live) may reduce agitation, enhance the participants' emotional disturbances and support mental orientation skills. Possible processes and sources of such outcomes include a facilitation of the neurogenesis, regeneration and repair of neuron when listening to music [27]. A well-known effect of music listening is experienced improvement of mood and relaxation in patients with stroke while body movements and changing respiration rate indicate improved arousal in patients with low conscious state [23, 28]. This can improve the participants' cognitive ability to interpret the information they receive from the environment correctly. Similarly, well-known music can create a more familiar environment, which subsequently encourages people to interact more with the environment, and thereby enhancing their awareness. The feeling of safety, which occurs with enhanced orientation to the environment, may contribute to reduced agitation [24].

The studies mentioned did not explicate in detail how suitable patient preferred music was assessed and selected. A taxonomy developed by Wärja and Bonde [29] classifies music in three main categories each with three subcategories with increasing levels of intensity and complexity. The three main categories are 'Supportive Music', 'Mixed Supportive/Challenging Music' and 'Challenging Music'. Agitated behavior may decrease using samples from the category 'Supportive Music' which is characterized by predictable harmonic and melodical progressions, a positive mood, steady rhythm and no or very little tension, leading to a low intensity profile. Emotional material evoked by 'Supportive Music' is easy and safe and has either a static quality or a slow development supporting presence and orientation.

Aim

The aim of this study was to explore the intensity in agitated behaviour before and after an intervention of listening to personalized playlists with patient-preferred music, categorized as 'supportive music', in patients with severe acquired brain injury (ABI) at a sub-acute rehabilitation hospital.

Methods

Design

This study was a quality development project conducted as a single case experimental design (SCED) as described by Smith [30] as useful for identifying evidence-based practices. SCEDs facilitate a possibility to observe patients under different conditions, manipulated by clinicians, with repeated measurements in each of the conditions [31]. The separate studies of several participants are common in SCEDs, especially for the purpose of replicating the effects of the intervention, which makes the SCED ideal to explore the effect of listening to preferred music on measured agitated behaviour after acquired brain injury.

The statistical analyses were conducted using "Microsoft excel" version 2010. The present case study involves two units of visual analysis: a group level and an individual level for seven patients who received five or more interventions. Visual analysis is adept at determining intervention effect of particular relevance in real world applications [32]. Even though the study design is unfitted for statistical analysis, a two tailed t-test on ABS scores pre-post music intervention has been performed on all patients' first music listening intervention in order to explore tendencies in the results.

Participants

Setting and study population

The study took place at a semi-intensive ward at a highly specialised rehabilitation hospital. Patients are admitted when they are circulatory and respiratory stabile varying between 1-2 weeks up to 1-2 months after the injury. The onset of agitated behavior is correlated to the progress of conscious state and varies from admission at the rehabilitation hospital to after weeks stay. Typical interventions to prevent and reduce agitated behavior involved environmental adjustments to adjust the number of stimuli and to promote a stable circadian rhythm [7]. The recent environmental adjustments focus on circadian light, music and systematic reorientation [33]. In this setting, activities and stimuli from the environment are carefully adjusted in order to prevent over-stimulation and confusion. Furthermore, the daily program is structured to alternate modified activity and rest in order to allow patients to consolidate re-acquired skills. Participation in rehabilitation efforts is generally promoted by physical or verbal guidance, redirection and reassurance in performing simple functional tasks and activities of daily living [7, 34].

Inclusion criteria included agitated behavior following ABI defined by Agitated Behavior Scale (ABS) score ≥21 [35], age ≥ 18 years, Rancho Los Amigos Scale (RLAS) score from 2-5 indicating cognitive impairment ranging between responding inconsistently and non-purposefully to a hyperactive state with bizarre and non-purposeful behavior or confusion with difficulties in making sense. RLAS scale is divided into eight stages according to the state of consciousness and cognitive status and describes the various behavioral and cognitive statuses after a brain injury [36]. Exclusion criteria were patients <18 years or non-agitated behavior, patients that were unable to hear, patients that scored below 2 on the RLAS and patients with ABS scores above 35 where immediate medication is required. Participants were consecutively screened by the usual clinical staff, and enrolled whenever they met the criteria.

Approvals and ethics

This case study was approved by the Data Protection agency case number 1-16-02-210-16. Data was gathered as integrated part of daily practice in accordance to Danish legislation. Written informed consent was obtained from the relatives, who participated in development of personalized playlists.

Measures and materials

Data on demographics, prescribed pharmacological agents, and rehabilitation interventions were extracted from medical records. ABS and systolic and diastolic blood pressure were measured before and 15 minutes after the intervention, and the pulse was monitored continuously. Blood pressure and pulse assessments were gathered using portable monitors as a part of usual clinical practice. The emergence and severity of agitated behavior was measured using the Agitated Behavior Scale (ABS) [35]. ABS is the only validated assessment tool for measuring agitated behavior in rehabilitation settings [8]. ABS has 14 items. Each item is rated on a four-point scale from 1 (absent) to 4 (present to an extreme degree). Based on this, the total score is between 14 and 56. A score of ≤21 is within normal limits, scores between 22-28 represent mild agitation, scores between 29-35 represent moderate agitation, and scores >35 represent severe agitation. The ABS is validated in patients with TBI and has excellent test-retest reliability [35], inter-rater reliability and internal consistency [37]. Furthermore, it has been found appropriate for patients with non-traumatic ABI [20, 38].

Intervention

The intervention was 15 minutes of listening to personalized playlists including patient-preferred music with a supportive profile located in the therapeutic environment at the bedroom without planned simultaneous activities. The intervention period was defined as episodes of agitated behavior within 3 days and evenings in total from the time of inclusion. The music listening intervention was the primary treatment initiative before other non-pharmacological interventions when the intensity of agitated behaviour was registered by the staff as increasing or persistent. The intervention could be repeated with a time interval of 3 hours taking the impact of any supplementary medication into consideration.

Composition of a playlist and the music intervention

Music can activate complex sensory processes in the body, brain stem, thalamus, cortex, and structures assisting the cortex [39]. Music perception is an active process involving a number of different neural networks, and expectation as well as prediction are essential elements in this process [40]. In one study, participants listening to classical piano music had activity in amygdala related to tension in the music [39, 41]. Music that is consistent, tranquil and repetitive with only little dynamic variation – i.e. with a supportive intensity profile - activates the parasympathetic nervous system and the regulation of pulse, breath, heart rate and attention in the brainstem (40). Both musical and individual factors need to be considered when selecting appropriate music for reducing agitated behaviour in the patient. It is important that the style and genre of the music is familiar and/or predictable, and that the patient can relate to the music. If not, the music will often be experienced as noise, disruption and it may evoke frustration [42]. Preferred music helps the patients to reconnect to their pre-morbid personality and confirm their identity. It is important to select music that primarily evokes and stimulates positive moods and emotions [29]. Selecting music that is recognizable and acceptable is ensured by following the so-called iso-principle [29, 42].

The construction of the individual playlists was based on a taxonomy that categorizes music in increasing levels of intensity and complexity [29]. The patients' preferred music numbers were assessed using the sub-category 'supportive music' and the each personal playlist was composed by pieces with a steady rhythm, clear and predictable melody, simple harmonic progressions [29, 43], a positive mood, and a tempo between 60-120 beats per minutes. Transitions between the pieces were made as smooth as possible.

Three persons from the usual staff at the ward were trained by an experienced music therapist to apply the research principles, based on the above mentioned criteria for selection [29] and administration of music. Relatives were involved to collect 1. A personal playlist of music, 2. CD's or 3. Information of genres and styles preferred by the patient. One of the trained persons selected 4-6 pieces of music corresponding to the criteria of the main category 'supportive music' and the subcategories 'supportive and safe field' and 'supportive and opening field'[29]. The music was saved as a playlist and played from a PC attached to Dynaudio XEO 3 loudspeakers.

Results

Data

Data on the seven included patients demographics, prescribed pharmacological agents, and symptoms of agitated behaviour were extracted from medical records (table 1).

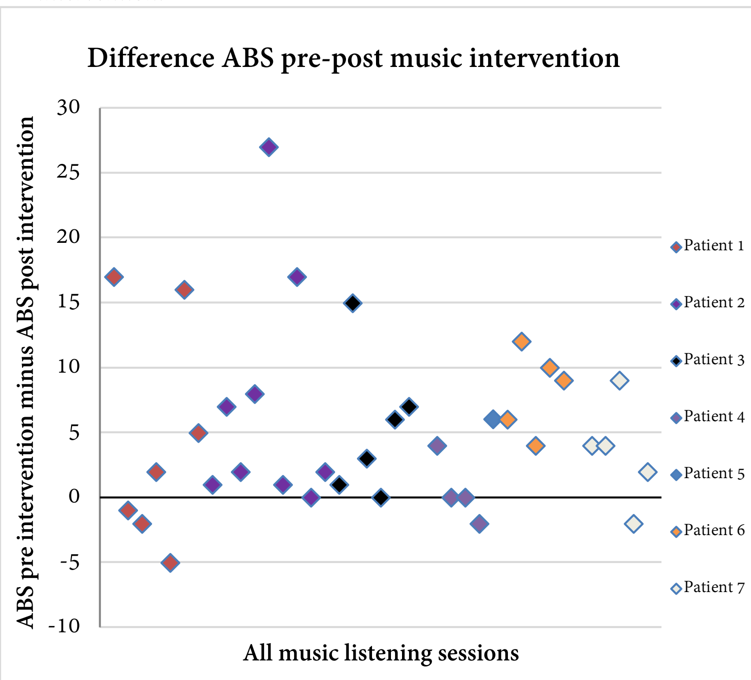
Table 1: *Characteristics of the seven included patients*

PT	Sex/age	Diagnosis	Days from injury to intervention	Demography	Symptoms	Medication addressing agitation
1	M/70	TBI	111	Married, retired craftsman. Hardworking and energetic in domestic duties, garden and fitness. Appreciates family and friends	Pulling at tubes, restraints, etc. Restlessness, pacing, excessive movement.	Quetapin Accord 25 mg max 3 times a day
2	M/65	Stroke	45	Married, retired from self-employed craftsman, active in garden, nature and workshop	Periods of agitation with symptoms in all items of ABS score	Sertralin 100 mg x1 (pre injury anxiety) PN Oxacepax 7,5 mg max four times a day
3	F/74	TBI	50	Married, retired, physically and socially active	Impairment of awareness and concentration, easy to distract, rocking, self-stimulating and repetitive behavior	Quetiapin 25 mg x 1 and PN max 3 times a day
4	M/21	TBI	20	Living alone, forest worker, appreciates to be alone in nature and gardening	Restlessness, excessive movement	Risperidon 0,5 mg x2 samt PN PN Quetiapin 25 mg
5	M/71	TBI	44	Married, retired farmer	Pulling at tubes, restraints, etc. Restlessness, pacing, excessive movement. Impulsive, low tolerance for frustration.	Quetipin 25 + 50 mg dgl PN Serenase
6	M/69	Stroke	61	No information available	Psychomotor over activity. Pulling at tubes, restraints, etc	Lyrica 75 mg x1
7	M/69	Stroke	61	No information available	Psychomotor over activity, Pulling at tubes, restraints, etc	Lyrica 75 mg x1

The seven participants' received in all 37 music listening interventions. The duration of various disturbances in consciousness and general impairment in fundamental cognitive functions after a brain injury is highly heterogeneous. Therefore the number of episodes with agitated behaviour and thus the numbers of listening interventions differed between the participants ranging from one to nine music listening sessions. The intervention was provided when the professionals assessed agitated behavior measured by the 14 specific items in the PTA scale. The most prevalent symptoms in each case are described in Table 1.

At group level the difference in ABS-score pre and post interventions are highly variable. In five interventions the ABS score increased with one to five points. No difference in ABS was measured in four interventions while the majority showed decreasing ABS scores between 1 and 27 points (Figure 1). From a visual point, the ABS score pre intervention is higher than ABS score post intervention. The two tailed t-test on ABS scores pre-post music intervention on all patients' first music listening intervention (M=24, SD=5,5) indicate that the music listening may have had a significant effect on ABS score (p=0,025).

Figure 1. *Differences in ABS score before and after the music intervention.*



There were minor differences in the participants' pulse pre and pulse post the music listening with changes between minus 36 and plus nine beats per minute (figure 2). Similarly, the readings on systolic and diastolic blood pressure indicated a small decrease in general within the range between plus 29 and minus 24 (figure 3).

Figure 2. *Differences in pulse before and after the music intervention*

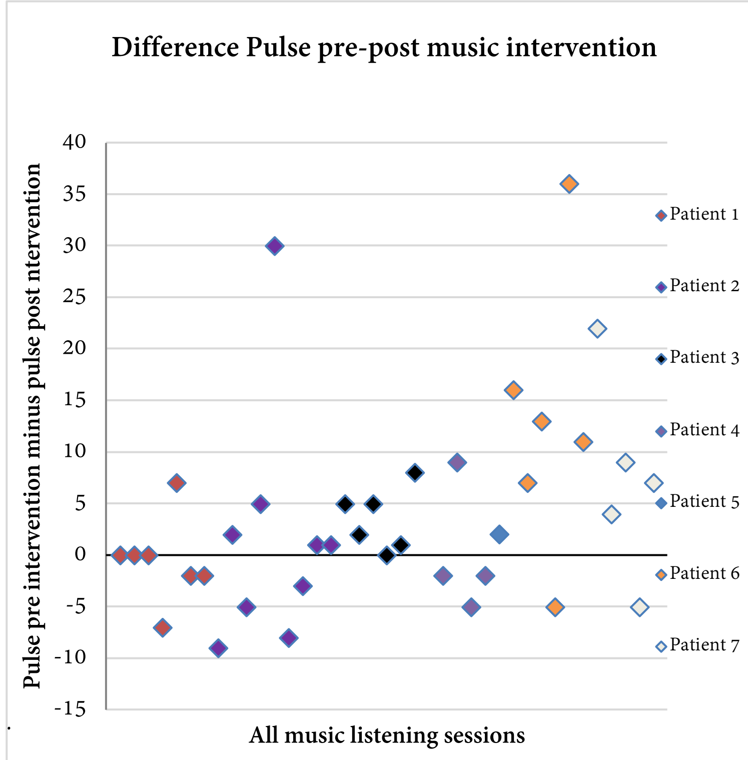
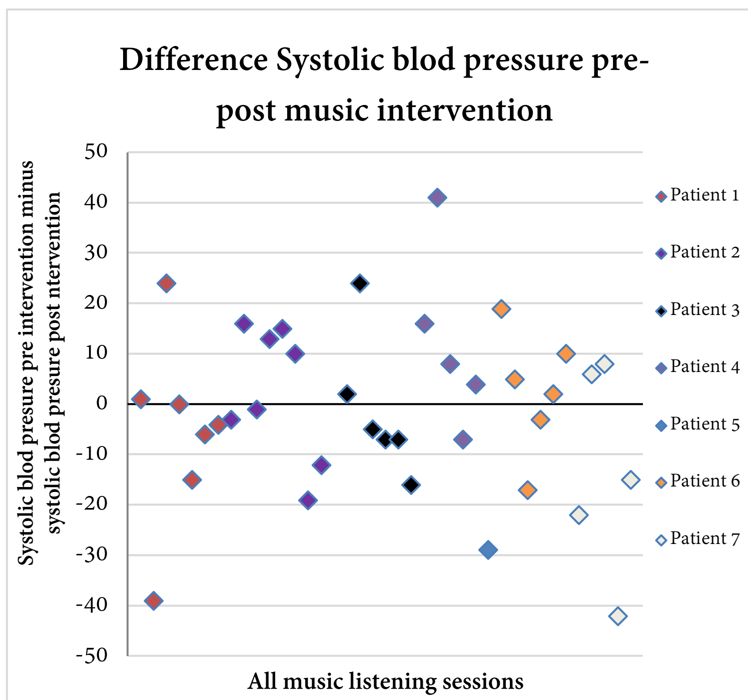


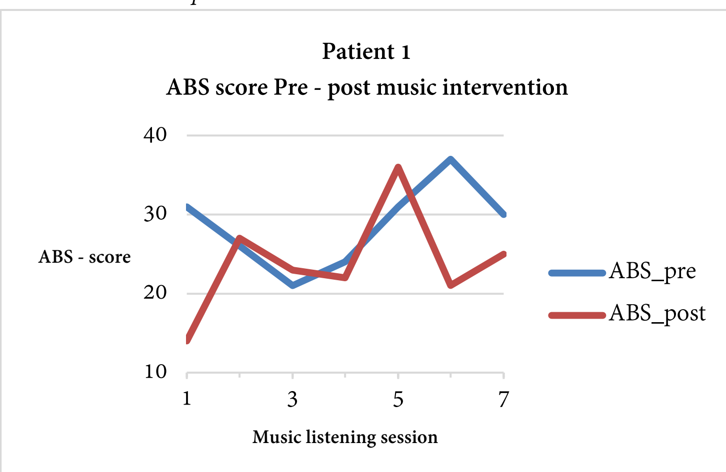
Figure 3. *Differences in systolic blood pressure before and after the music intervention*



Five patients received interventions. In the following the possible influence of the music interventions on the intensity of the agitated condition will be shown as measured by ABS score in each of these individual cases. The intensity of agitation pre music intervention varied from mild (ABS total scores 22-28) to severe (ABS total score >35).

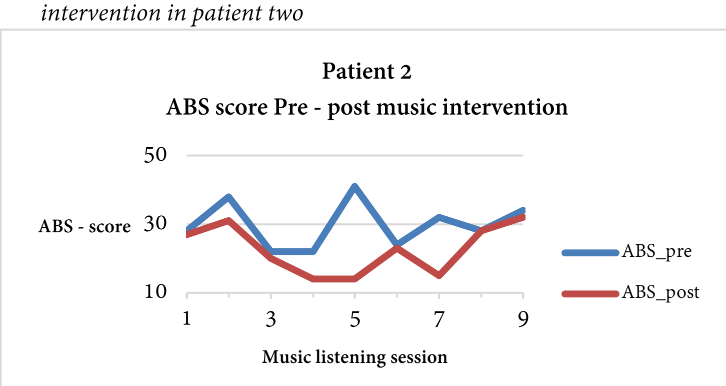
In patient number one the ABS-score pre and post interventions are highly variable. In three interventions the ABS score increased within one to five points while decreasing ABS between two and 16 points were measured in four interventions (Figure 4). A visual point indicates the intervention might have no influence on the agitated condition as the outcome mirror both decreasing and increasing differences between ABS measurements with a degree of coincidence between the lines.

Figure 4. *Differences in ABS score before and after the music intervention in patient one*



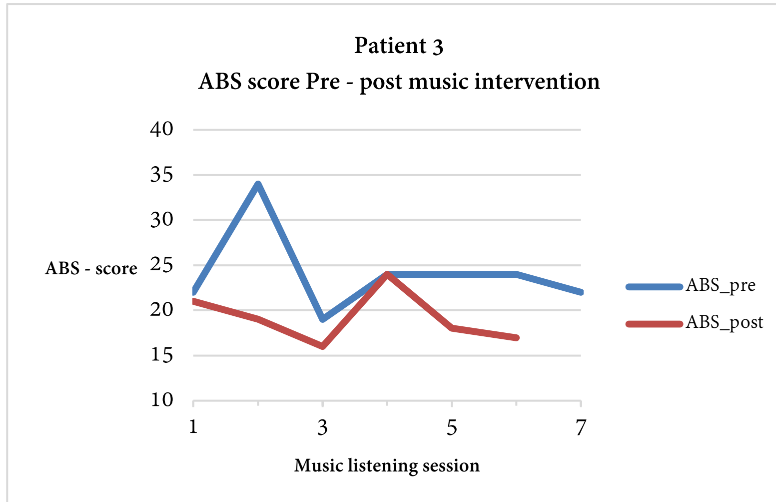
In patient number two the difference in ABS-score pre and post interventions show one unchanged and eight decreasing values between one and 27 points in the nine interventions (Figure 5). From a visual point the ABS scores pre intervention is higher than ABS score post intervention

Figure 5. *Differences in ABS score before and after the music intervention in patient two*



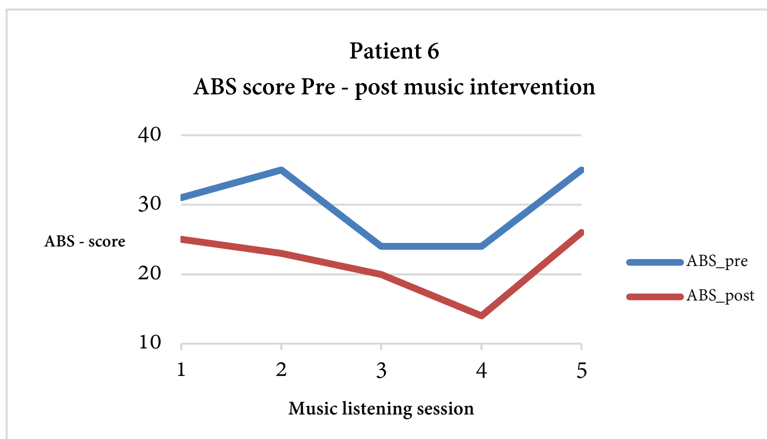
In patient number three there was five ABS scores decreasing between one to 15 points from pre to post intervention and one value remained unchanged. Following this the post interventions ABI seems lower than the pre intervention measurements (figure 6).

Figure 6. *Differences in ABS score before and after the music intervention in patient three*



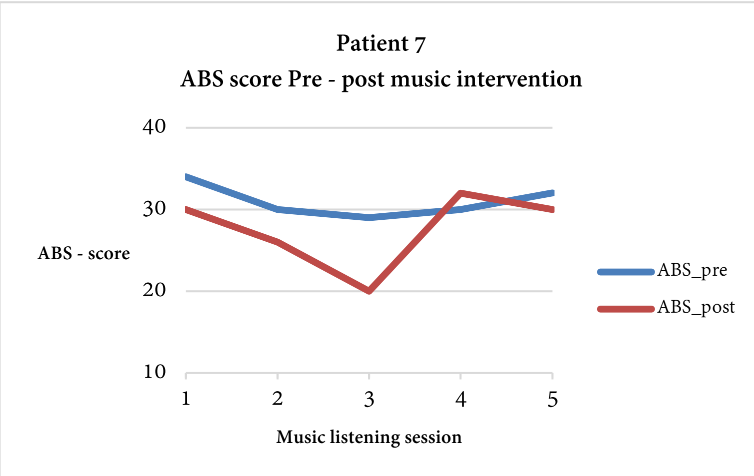
Patient number six received six music interventions, but due to one missing ABS measurement, there are only five pre and post registrations. All registrations showed decreasing values between four and ten points (figure 7)

Figure 7. *Differences in ABS score before and after the music intervention in patient six*



Patient seven received five interventions. In one intervention the ABS score increased two points, and a slightly decreasing ABS between two and four points was measured in four interventions. However, the visual impression is minor differences suggesting lower post-intervention measurement (fig 8).

Figure 8. *Differences in ABS score before and after the music intervention in patient seven*



Discussion

At group level, the ABS score pre intervention was higher than ABS score post intervention.

At the individual level, five or more patients received more than three interventions. Increasing intensity of the agitated condition was measured in four out of 32 ABS measurements. Three of the increasing pre and post intervention ABS values were related to the same case. The remaining four cases showed a decrease in the ABS measured before the music intervention to 15 minutes after. These changes suggest that the music intervention could reduce agitated behaviour, as measured on the Agitated Behavior Scale. Furthermore, the music listening phase may have led to reduce pulse, although only modest changes were recorded. The music listening intervention showed no effect on blood pressure.

The findings must be read with caution due to this study's limitations in regard to: A sample size of seven subjects (n=7), the observational character in using the ABS scale, no randomization and no control group. Therefore, we are unable to claim that the observed effect is caused by the preferred music, or whether a similar effect could be obtained in a condition of silence. Furthermore, the variability in the condition of agitated behaviour is well-known in relation to both intensity and duration [44]. This variability is an integrated part of the illustrated changes related to the music interventions and may blur the findings. Despite the fact that ABS is a validated instrument to measure agitated behaviour, the professionals` subjective assessment may have been influenced by their former experiences of music interventions, which can have biased the results towards higher estimated effect. Finally, all patients had severe cognitive disturbances and only a few had developed personal playlists (recorded musical preferences) from pre-injury. Therefore, the personal playlists were based on information from the relatives. This leaves a risk of interpretation bias in the relatives' selection of CD´s or musical styles that may have influenced the patient's ability to recognise the music, potentially increasing discomfort [39, 40].

The findings are in line with the preliminary evidence supporting the effectiveness of preferred music to reduce agitation in persons with dementia and traumatic brain injury [26, 45]. Furthermore, the role of music in cognitive rehabilitation is documented in neurologic music therapy [23, 44]. Interestingly, research studies about the effect of music therapy on emotional changes are still scarce and of limited quality [46-48]. We found patterns that may illustrate the effects of the intervention, which can be explained by positive emotional responses, including the patient's experience of increasing comfort, relaxation, and calmness induced and supported by music integrated in a familiar environment [22]. These changes can be related to the selection of music from the category 'Supportive Music' [29] with the assumed reduced activity in amygdala, or activity that evokes positive emotions [39, 41].

The study has been preceded by other studies of equally modest population sizes, e.g. Baker et al. [24]. It matches the clinical possibilities and implications due to the sensitive state of the patients. Patients should not be exposed to unnecessarily stressful stimuli while increased knowledge of potentially beneficial interventions is still demanded. However, to further guide evidence-based clinical practice controlled studies with bigger sample sizes are warranted [49].

In spite of the above described limitations, this study suggests that listening to personalized playlists of preferred music with a supportive intensity profile may be a valuable tool in a familiar therapeutic environment, using controlled, recognizable stimuli with no side-effects to reduce agitated behaviour.

Conclusion

This study suggests that listening to personalized playlists of preferred music with a supportive intensity profile may reduce the intensity of agitated behaviour following an acquired brain injury in the sub-acute phase, as measured with the Agitated Behavior Scale. Furthermore, the music listening intervention may have contributed to reduced pulse. Due to the small sample size and few measurements, further research is warranted. However, since music listening is an easily administered, low-cost intervention with no obvious side-effects and an observed effect on agitated behaviour, it is recommended that clinicians consider the intervention as a supplement to treatment as usual.

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