Full-Length Article

The Potential of Rhythmic Sensory Stimulation Treatments for Persons with Alzheimer's Disease

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Abstract

Background: Rhythmic Sensory Stimulation (RSS) is a treatment being implemented for persons diagnosed with a variety of disorders such as fibromyalgia and Alzheimer's disease (AD). This paper provides qualitative results of observations and interactions of AD study participants who received both RSS and visual stimulation sessions for 6 weeks. A case vignette is also provided.

Objective: The study proposed that RSS could stimulate the auditory and somatosensory system at 40Hz with the potential for improvements in cognition for persons with AD.

Method: 18 participants at three stages of AD participated: mild, moderate and severe. Participants received a total of 13 sessions in this AB cross-over design study. Qualitative content analysis was used to analyze the qualitative data.

Results: Qualitative findings from the study support RSS as a potential treatment for persons with AD to increase alertness, stimulate discussion, and increase interaction and awareness of surroundings.

Conclusion: Further research is needed to explore the effect of the frequency within the sessions provided, the duration of effects, and whether AD severity interacts with the RSS treatment. Further investigations could also study the effect of auditory 40Hz stimulation alone, as well as the inclusion of music listening during the RSS sessions.

Keywords: ***alzheimer's disease, sound stimulation, cognition, alertness*** multilingual abstract | **mmd.iammonline.com**

Introduction

A projected 35.6 million people live with dementia worldwide and by 2050 estimations predict this number will increase to 115 million [1]. Dementia is characterized as the gradual loss of higher cognitive functioning. There is behavioral and psychological symptomology common to individuals living with dementia such as: dysphoria, anxiety, apathy, psychosis, aberrant motor behavior, irritability, aggression, eating disturbance and sleep disorders [2]. The management of dementia varies. However for persons living with Alzheimer's disease (AD) there is no identified cure, and no treatment that slows progression of disease. With such a dramatic increase in prevalence of persons with AD and other forms of dementia, it is essential to develop treatments that may reduce the debilitating symptoms associated with these diseases.

Rhythmic Sensory Stimulation (RSS) is one such new treatment that is being utilized with persons diagnosed with a variety of disorders such as fibromyalgia, tinnitus, and AD [3]. RSS can involve vibro tactile stimulation of mechanoreceptors, auditory stimulation of the auditory system, or visual stimulation of the optic system. This is done with regular pulses at a target frequency such as 10 times a second (10Hz) or 40 times a second (40Hz). The stimulus results in a neural response – like a nerve firing into the brain – at the frequency of the stimulus. Therefore if sound and vibration stimulate the neurons 40 times a second, there is an increase in coherent neural oscillation, or electro-potential power at the stimulus frequency. Research shows that steady-state 40Hz neural activity is normal in healthy brains and is related to brain connectivity [4,5,6] making it essential in cognition. Persons with AD have less electro-potential power at the 40Hz level than those with age-matched 'normal' brains [4], but there is evidence that 40Hz oscillatory power can be "driven" with vibration [7]. This study proposes that RSS can

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Amy Clements-Cortés, PhD, RP, MTA, MT-BC, FAMI. 56 Destino Crescent, Woodbridge, Ontario, L4H 3E1, Canada; Email: notesbyamy2@yahoo.ca | COI statement: Bartel receives royalties for the VST1000 – Somerset Group for sound and Headwaters Corporation for design and consulting. Freedman received honoraria from Eli Lilly Canada Inc. for participating in consultancy and advisory board meetings. He is also listed on a provisional patent related to methods and kits for differential diagnosis of AD vs. frontotemporal dementia using blood biomarkers and may be listed on the planned patent application.

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stimulate the auditory and somatosensory system at 40 Hz, increasing the functional prominence of the steady-state 40 Hz oscillation, which could lead to improvements in cognitive performance in AD patients.

This report provides descriptive and qualitative results, including observations and interactions, of the experiences of AD study participants receiving RSS and visual stimulation sessions. All 18 participants are described along with the presentation of one case vignette. A scientific report that focused on the quantitative results of this study was previously published, containing the hypothesis, methodology, quantitative, and minimal qualitative results and implications for future studies [8]. While quantitative results indicated statistically significant results for RSS treatment to improve cognition in as few as six sessions, the qualitative results allow examination in greater detail of important themes and interactions to further a clinical understanding of how this stimulation supports improved cognition.

Treatment and Methods

This pilot investigation sought to assess whether applying RSS (sound driven vibrotactile stimulation to the somatosensory system) at 40 Hz in persons diagnosed with AD would improve alertness, clarity, and/or short-term memory. This study hypothesized that: repetitive RSS at 40Hz would produce an increase in neural rhythmic oscillatory coherence which would subsequently contribute to improved cognition in patients at 3 stages of AD when compared with repetitive non-rhythmic visual stimulation sessions.

The substitute decision makers for all participants provided written consent to participate in the study, and participants were read an assent letter and asked for their assent to participate. Participants received six (40 minute) sessions of both treatments in this AB cross-over study: Treatment A: 40Hz sound stimulation and Treatment B: visual stimulation using DVDs. RSS stimulation was provided for 30 minutes administered through the Next Wave chair [9] and the visual stimulation consisted of watching 30 minutes of a DVD [10] specifically designed for persons with AD.

The outcome measures that were described in a previous report [8] included: the St. Louis University Mental Status Test [11], Observed Emotion Rating Scale [12], and behavioral observation by the researcher. During the intake session the Mini Mental State Exam (MMSE) [13] was collected from the participant's chart. The SLUMS test has a maximum score of 30 and any score lower than 20, indicates dementia [11]. The qualitative data consisted of: (a) dialogue that took place between the participants and the therapist who provided the treatment sessions. The therapist sat beside each participant while he/she received treatment and recorded the verbal discussion (if any) that took place on the Stimulation session observation form (Appendix A). (b) Comments recorded by the therapist on the observed emotion rating scale, regarding participant comments, affect and behavior [12]. (c) Dialogue or comments and behaviors of the participants as they walked with the therapist to and from the treatment sessions from the pick up or waiting area, which were documented by the therapist in the participant's notes on the session date. Examples of observed behaviors included: eyes open and looking around the room, fidgeting, body movements or gestures, facial affect and expressions, increased verbalizations, etcetera. Eighteen participants completed the treatment, 10 male and 8 female, and there was an equal breakdown of persons with mild, moderate, and severe AD. All participants were recruited from the research database and/or healthcare facility in a large metropolitan city. Participants whose names were on the database and who fit the inclusion criteria were invited to participate. Additional participants were invited from the community day program. As explained above, analysis in this paper focuses only on qualitative results.

Data Analysis

The therapist who delivered the treatment sessions analyzed the research observation notes (including a, b and c noted above) alongside two research assistants (RAs). These RAs were certified music therapists holding the MTA credential and were blinded to the treatment interventions. Both had worked previously with this client population, and had also coded qualitative data in prior studies. The therapist and RAs studied the data sources and acknowledged important behaviors, accounts, or statements. Qualitative content analysis was used to analyze the data and implemented to create the descriptive codes (conventional content analysis) to identify the principal significance. Following this, codes were arranged into comprehensive themes identifying responses, dialogue, and behaviours during the treatment sessions [14]. The final list of themes was reviewed by the therapist, and the RA's. We sought to confirm the interpretational accuracy of the results. The assistance of the RAs was included to ensure objective analysis of the results via inter-coder reliability [15].

This analysis team met to discuss the results and the final list of themes was determined by the therapist who provided treatment sessions.

Results

To characterize the qualitative observations and ratings of the participants in this study, a single case study typical of the study results is presented. A pseudonym ("Louis") will be used. A summary of the treatment effects on the three subgroups based on AD diagnosis is also presented for both the RSS and the video treatments. As previously noted above the quantitative results of the study have been published [8] and indicate that data submitted to regression analysis produced positive slopes for 40 Hz treatment, demonstrating

an increasing SLUMS score over time (an increase of about .5 for each treatment), and a virtual 0 or negative slope with DVD treatment.

Case Vignette: Louis

Louis is a 68-year-old male diagnosed with moderate AD. When treatments began, his MMSE score was 16 out of 30. Six months prior to the beginning of treatment, his MMSE was 21 out of 30. He was on a variety of medications at the time of treatment sessions including: donepezil, atorvastatin, citalopram and a variety of vitamins. He received six sessions of RSS followed by six sessions of visual stimulation. During the first RSS session, he asked, "*What am I doing here?*". Five minutes into the treatment, he had his arms folded over his chest, and presented a neutral affect with his eyes open. At 10 minutes his breathing appeared to be in synchronization with the amplitude modulation of the vibration. At 15 minutes he was actively looking around the room, fidgeting, and commenting on the items. His eyes were fully open at 20 minutes and the arousal appeared to be strongest at the 15-minute mark, and at the end of the treatment.

Session two of the RSS treatment was similar to session one, but there was a noticeable change in session three. During session three, Louis made jokes, talked about his career and work as an architect, school colors, and on the walk back from the treatment room to the waiting area he discussed the art on the wall with the therapist. In session four, he questioned "*Why am I here? Can I talk?*" and made some short ponderings or expressions: *"A chair is still a chair", "A house is not a home", "Have you heard of Burt Bacharach? He composed a lot of songs"*. Louis began singing songs and tapping his hands at 10 minutes, and then started whistling. When the treatment was finished he talked to the therapist about his marriage, and his challenges with his partner to have children. At the beginning of session five, Louis recognized that he had been to the treatment room before. After five minutes into the RSS treatment, he shared stories about growing up in his country, what languages they spoke, and gave examples of typical names of persons from that country. At 15 minutes he asked, *"Is this a hospital? My wife is a nurse. The hospital is nice, they help you"*. At 20 minutes he asked: "*Have you been to my country? Do you speak another language? What's my first language?*". He then began to speak in Spanish, and at the end of the session he wanted to share politics of his country with the therapist. He talked about famous politicians and asked if the therapist knew these persons. He appeared to be very alert. Session six was similar to session five, in that there was a lot of discussion on languages, and he began to share examples of phrases in Spanish, Italian and French.

The overall trend in sessions suggested that the RSS treatments were effective in stimulating discussion. One external factor causing the increase in discussion could be that he was more comfortable with the therapist over time. Louis generally began sessions indicating signs of pleasure, smiling, laughing, alongside small signs of anxiety (uncertainty or nervousness) about what he was going to have to do. After the 40 Hz stimulation sessions there was no real change in these indicators; he still demonstrated signs of pleasure and alertness, and some anxiety when asked the questions on the SLUMS.

For the visual stimulation sessions, Louis generally began in an alert state, but alertness declined from a rating of 4 at the beginning of the session to a rating of 2 by the end of sessions (as assessed by the observed emotion rating scale). Affect was high at the beginning of the session, generally rated at a 4 or 5, but dropped to 2 or 3 and appeared to be flatter and dull throughout the visual stimulation. Overall Louis was much less talkative during the DVD sessions. After approximately 10 minutes during all six sessions he frequently tapped his fingers, and several discussions demonstrated that he appeared confused and bored by the videos. During one session, he said "*This will put you to sleep. Where is this beach? I don't swim. Are we supposed to sleep or what?*". During session three after 15 minutes he said, "*I forget why I am here, is this a test?*". In session five after 10 minutes he appeared bored of the video, looking around tapping his hands and moving his thumbs and said "*Why are we watching this? You call this a movie?*".

Louis displayed pleasure and alertness at the beginning of each session. From sessions three to six of the videos, there was some anxiety (restlessness, desiring to be done the session). The SLUMS test appeared to cause some of the anxiety but there was also anxiety from the boredom of watching the video and questioning why he was watching it. Overall, after the visual stimulation session, Louis was able to answer the SLUMS question about naming animals and the city he was in, and could identify the triangle and the largest object. After the RSS sessions he was able to answer these questions with an improved ability to name animals and was also able to answer questions from the story, and recite numbers backwards. He never was able to correctly answer the year or day of the week, or the math questions post either treatment sessions.

Themes found for Mild, Moderate, and Severe AD participants

Table 1 provides a summary of the qualitative themes found when participants received RSS and visual stimulation sessions. A list of participants that each theme corresponds with is provided. Note that participants are numbered from 1 – 20, but participants 8 and 11 withdrew from the study, and are not included in analysis below.

DVD THEMES	Total & (List of Participants Who Shared This Theme)	40HZ THEMES	Total & (List of Participants Who Shared This Theme)
Boredom	**15** (1- 5, 6, 9, 10, 13-17, 18, 20)	Increased alertness	**11** (5, 6, 9, 10, 13, 14, 16, 17, 18, 19, 20)
Increased agitation/ anxiety	**7** (1-3, 9, 10, 16, 19)	Increased awareness of surroundings	**13** (1,2,4, 5-7, 9, 12-14, 17, 18, 20)
Increased suspicion/ confusion	**3** (13, 14, 19)	Increased clarity	**4** (1, 6, 10, 16)
Quiet	**7** (6, 7, 12, 15, 17, 18, 20)	Increased interaction	**13** (1, 2, 4, 5-7, 9, 10, 14, 16, 17, 19, 20)
Restlessness	**3** (1, 2, 19)	Reminiscence	**6** (1 ,2, 4, 5, 6, 20)
Sleep	**7** (4, 5, 7, 9, 16, 17, 20)	Stimulation of discussion/story-telling	**13** (1-7, 9, 10, 14, 16, 17, 20)

Table 1: Qualitative Themes

Mild AD participants. During RSS Sessions, mild AD participants appeared to become more alert (P1, P2, P10) and recounted interesting stories from the past (P1, P2, P5, P10, P17). They also became more aware of their surroundings and commented on what they saw (P1, P2, P5, P17, P18). Several participants seemed to find the treatment relaxing or commented that they enjoyed it, or appreciated it (P5, P10, P17). During the video sessions mild AD participants commonly appeared to be bored and even stated that they were (P1, P2, P10, P17). There were some signs of increased anxiety as well as restless and fidgety behaviour (P2, P10). Several found it made them tired and sleepy (P5, P17), and some showed signs of confusion (P2, P5).

Moderate AD participants. During RSS Sessions, moderate AD participants showed signs of increased arousal that manifested through increased verbal output like telling stories of the past (P4, P6, P14. P16), increased energy and physical action like moving in the chair, slamming arms while telling stories, and even jumping up (P6, P14), increased voice volume (P6), singing (P3), and, general alertness (P20). During the video sessions moderate AD participants demonstrated some confusion (P3), boredom (P4, P6, P14, P16), sleepiness (P4), anxiety and restlessness (P4), and were less talkative (P6, P14, P16).

Severe AD participants. Generally the severe AD participants showed less engagement in both treatments, less coherent verbal communication, and several participants with particularly severe cognitive impairment showed little observable difference between the two treatments. During RSS sessions there was more evidence of interactive verbal communication (P7, P9, P13, P19), alertness (P9), relaxing behavior (P12) and greater awareness of context (P13). During video sessions participants showed greater signs of being bored and tired (P9, P13), agitated or restless (P9, P12), or producing outbursts (P19).

DVD Stimulation Themes

Boredom, increased agitation and increased anxiety. Boredom was a theme for 15 out of the 18 participants. Direct quotes such as,"*I am bored. When is this going to be over?"* and behaviours such as twitting thumbs is evidence that supported this theme. While not as prominent as boredom, seven participants still contributed to the emergence of the increase agitation and anxiety theme (four females and three males). This theme was evenly spread out among the three classifications of AD.

Increased suspicion/confusion. This theme surfaced for three participants, two severe AD and one moderate AD. Participant 19 for example appeared to be the most impaired according to the therapist administering sessions. It is therefore not surprising that she experienced increased confusion, especially with attempting to answer questions on the SLUMS test of which she rarely could complete, resulting in her scores only ranging between 3 and 4 during both the RSS and visual stimulation sessions.

Quiet. The "quiet" theme was evident from seven participants and occurred fairly evenly among male and female participants as well as the three levels of AD. It appeared logical that persons with severe AD might be quieter in the DVD sessions, but for the two persons for whom this theme surfaced and who were "mild" AD it is curious. Participant 17 for example was very talkative in the 40 Hz sessions, yet did not seem to find anything stimulating to comment on with respect to the DVD. The results are also interesting for participant six who was overly talkative and animated in the 40 Hz sessions but quiet during the DVD, confirming the observation that the DVD did not provide substantial stimulation of cognitive function.

Restlessness. This is a "small" theme as it was only evident in 3 participants but interestingly it was for two mild participants and one participant with severe AD. For the participants with mild AD, it seemed that the DVD was not engaging which caused them to become fidgety and wonder why they were there. For participant 19, the restlessness corresponded with her overall level of agitation and physical comfort.

Sleep. Sleep was a theme that emerged from 7 participants representing each level of AD. It is not uncommon for an older adult to potentially close their eyes and drift off, especially if they are not sleeping well and/or are

unstimulated. Sleep in these sessions appeared to be related to a lack of being engaged in the DVD. The DVDs were created to assist in relaxation, so sleep is also a natural outcome of that type of intervention.

40 Hz Stimulation Themes

Increased alertness, stimulation of discussion/storytelling, increased awareness of surroundings. The theme of increased alertness surfaced for 11 participants (five mild, three moderate and three severe). Of these 11, 8 participants also showed evidence of the theme of stimulation of discussion/storytelling, and nine participants showed increased awareness of surroundings. It appeared as though participants told stories and became more alert regarding their surrounding or vice-versa: they became more alert and it sparked storytelling and discussion. These factors seemed to feed into an increased awareness of surroundings.

Increased interaction and clarity. This was a large theme, and also corresponded with those participants who showed evidence of increased alertness, awareness of surrounding, and stimulation of discussion/storytelling. Increased clarity was a theme that was evenly split between males and females in the mild and moderate stages of dementia. It is not surprising that this theme did not surface for any persons with severe AD. While not a strong theme in this study for severe AD participants, it is an important observation and potentially requires a study with a larger group of participants to emerge more convincingly.

Reminiscence. The theme of reminiscence was present for 6 participants: Three participants with mild AD and three participants with moderate AD. Again, it is not surprising this theme did not emerge for participants with severe AD due to their impairment.

Discussion

Results support the hypothesis that repeated RSS sessions would produce an increase in neural rhythmic oscillatory coherence and that the visual stimulation sessions would not. Overall visual stimulation sessions did not appear to provide stimulation for these 18 participants, but rather induced quiet or sleepy states, perhaps because it did not produce any further connections in brain activity. The DVDs used in the study were designed to reduce agitation in persons with AD, and while the participants were quieter or more inclined to sleep during treatment sessions, the images did not seem to reduce anxiety; but rather added to anxious feelings as participants wondered why they were watching it. It materialized that 40 Hz treatments were successful at stimulating increased alertness, interaction, discussion and storytelling, and awareness of surroundings.

Limitations and Future Research

While the results are very promising, the researchers ideally would have had the participants receive the 40Hz treatments three times a week instead of just two. This was not possible in this study since many participants lived a long distance from the treatment facility and were unable to travel three times a week for this study. Further research is required to determine if there is a particular stage of AD (mild, moderate, severe) that would best respond to 40 Hz treatments. In addition the examination of individual case studies over a longer period would help further the understanding of whether there is an increase and/or maintenance of SLUMS scores. It is quite exceptional that the SLUMS scores on average increased 0.5 points on the SLUMS test after each RSS treatment. The reason it is exceptional is that AD is a degenerative disease and in only 6 sessions of RSS, participant's scores were steadily increasing. Further adding an imaging component to future studies alongside observation tools would provide additional evidence. Future research could also look into the use of a home device, which would enable greater frequency of the sessions, perhaps from five-seven times per week. For example, Sound Oasis VTS1000, is a device which produces very effective low frequency stimulation (RSS) and has available for download tracks that are very much like the stimulation used in this study (http://www. soundoasis. com/sounds/vibroacoustic-therapy/).

Conclusion

Descriptive and qualitative data support the potential of RSS treatment to promote increased alertness, stimulation of discussion/storytelling, awareness of surroundings and increased interaction in persons with AD. In a very short trajectory of treatments (six sessions of 40 Hz treatment) participants' SLUMS scores indicated statistically significant results for this treatment. Further research is indicated to further understand of the impact of such treatments, especially in the cases where there were increased duration of positive effects.

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Appendix A
Stimulation Session Observation

SID:

Date:

Time:

Time of Program	Corresponding Computer Program Aspects	Researcher Observations	Participant Comments
Opening Comments Once Seated on Chair			
1-5 Mins			
6-10 Mins			
11-15 Mins			
16-20 Mins			
20-25 Mins			
Closing Comments While Seated on Chair			