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Evaluation Of The Matadoc And Comparison Of Auditory Musical, Non-Musical, And Live Music Therapy Stimuli To Increase Awareness And Sense Of Self In Patients With Moderate And Severe Dementia: An Exploratory Case Study

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EVALUATION OF THE MATADOC AND COMPARISON OF AUDITORY MUSICAL, NON-MUSICAL, AND LIVE MUSIC THERAPY STIMULI TO INCREASE AWARENESS AND SENSE OF SELF IN PATIENTS WITH MODERATE AND SEVERE DEMENTIA: AN EXPLORATORY CASE STUDY

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Background: The severe stage of dementia (SSD) can cause the loss of self-awareness, affecting the proper assessment, treatment, and care. The Music Therapy Assessment Tool for Awareness of Disorders of Consciousness (MATADOC) is a validated and reliable tool to measure awareness in DOC populations and it might be able to track awareness levels in people with SSD. Also, there is a need to identify effective treatments with people with SSD since pharmacological treatments have shown limited and even negative results. Both live music therapy and music listening of recorded songs have evidence of positive effects.

Purpose: The purpose of this study is twofold: 1) To explore the use of the MATADOC for the assessment of patients with advanced dementia, 2) To compare the effects of live music therapy, recorded songs, and simulated presence therapy on increasing MATADOC scores and signs of an enhanced sense of self.

Method: A case study with four participants was conducted by a graduate student. Participants underwent 4 sessions of baseline assessment with the MATADOC. Afterward, each participant completed a 30-minute minute session of listening of recorded songs, live music therapy, and auditory simulated presence therapy, in a different order, and each one on a different day. Each condition was immediately followed by a single MATADOC session as a post-test. All the sessions were recorded on video for behavioral/thematic analysis. Caregivers were interviewed to provide reports.

Results: Most of the items of the MATADOC showed consistency with the level of deterioration of dementia. Two items of *intentional behavior* and *non-verbal communication* were consistently high with the four participants. While, the *vocalization* and the *emotional response* items showed consistency with the type of dementia, vocal/speech health, or location of brain damage. The protocol appeared to increase arousal, verbalizations, and/or mood. The researcher identified 18 adaptations or considerations to better fit the MATADOC to the dementia population. The musical conditions showed a better response in 100% of participants over control. Live music therapy showed a better response in 3 out of 4 participants and listening to recorded songs was better for the other remaining participant.

Conclusion: MATADOC might be able to identify awareness deficits with people with SSD, but it could be improved by including cognitive, sensory, and declining factors appropriate for the dementia population. The positive effects of live music therapy could be addressed to its flexibility and multimodal approach suited to be adapted to the individual strengths and needs of the participants. Listening of recorded songs appeared as an important treatment but with risks of harm. Five recommendations for future research were identified and outlined.

KEYWORDS: Active music therapy, Alzheimer's, Assessment, Auditory stimuli, Awareness, Dementia, Dementia treatment, Live music therapy, MATADOC, Music therapy, Recorded music, Sense of self, Severe dementia, Simulated presence therapy.

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N. A. E. C.

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CHAPTER I: INTRODUCTION

Dementia is a global epidemic. More than 50 million people in the world currently live with dementia and this number could rise to more than 135 million by 2050 (Prince, Guernchet, and Prina, 2013). As a progressive disease, the brain degeneration at the severe stage of dementia (SSD) can lead to a loss of self-awareness affecting proper assessment, treatment, and care (Zwijsen, Van der Ploeg, & Hertogh, 2016).

Loss of awareness and lack of consciousness has been observed in another neurologic diagnosis known as disorder of consciousness (DOC), and links between the SSD and DOC have been identified (Royal College of Physicians, 2013; Toms, Lawrence, & Clare, 2015). The Music therapy Assessment Tool for Awareness of Disorders of Consciousness (MATADOC) is a validated and reliable music therapy assessment tool to measure awareness in DOC populations. Studies are currently conducted to explore the use of the MATADOC with end-stage dementia, but results have not been published and there is a need to build data about it (Magee, 2018).

Also, there is a need to identify more effective treatments for dementia since drugs have shown limited and even negative results (Schneider, Dagerman, & Insel, 2006; Karlawish, 2006; Sakakibara, Igarashi, Takase, Kamei, & Nabeshima, 2015; Fink et al., 2020). Music therapy as a clinical discipline and profession is one of them (American Music Therapy Association, 2020). Within music therapy, both active and receptive techniques have shown consistent positive results with dementia throughout the stages (Sakamoto, Ando, and Tsutou, 2013; Garrido et al., 2017). However, the research on music therapy with the SSD is still scarce.

On the other hand, non-clinical recorded music listening with people with SSD have become a trending practice, especially after the release of the documentary *Alive Inside* (McDougald, Scully, and Rossato-Bennett, 2014) and care programs such as the *Music and*

Memory. Music therapists have shown their concerns about these practices regarding insufficient quality of training in the evaluation and management of the risks of harm (Swayne, 2014; Josefczyk, Hiller, & Heiderscheit, 2018). On top of that, music therapists tend not to use much recorded music due to academic and clinical training in live music. However, brain images have shown that music listening treatments improved functional brain connectivity in patients with early AD, and it points to a need of considering the role of recorded music listening in the clinical treatment of patients with dementia (King et al., 2019; Leggieri et al., 2018).

Therefore, this study attempts to increase the knowledge and resources for the assessment and treatment of patients with advanced dementia in music therapy. This, by exploring the use of the MATADOC with this population, and by comparing two musical conditions of live music therapy and listening of recorded songs against a well-evidenced non-musical auditory control, such as auditory simulated presence therapy. As a study case, the results could give lights about the ability of the MATADOC to assess and track awareness with patients with SSD and support future research for the validation of the MATADOC with SSD. Also, the comparison of treatments could show differences, limits, and effectivity of each condition with individual cases, in terms of diagnosis, level of deterioration, and support replicability with a larger sample.

In the beginning this study aimed to work with patients at the end-stage of dementia and assess only *awareness* through the MATADOC, but this was difficult as two out of five candidates died before starting the intervention. Consequently, the researcher expanded the population to include participants with moderate dementia and moderately severe cognitive decline and turned to find changes through the progression of the disease. Since patients with moderate dementia do not show severe loss of awareness, a second and more appropriate construct of *an enhanced sense of self* was taken from the recent publication by Baird and

Thompson (2018). In few words, the theory suggests that music can access and stimulate the various parts of the self, resulting in an enhanced sense of self. Therefore, the approach of this study was to focus on both theoretical constructs of *awareness* and *an enhanced sense of self*, by gathering the evidence of both populations DOC and SSD regarding auditory function, processing of music, assessment, and treatment.

Research Purpose Statement

The purpose of this study is twofold:

1) To explore the use of the MATADOC for the assessment of patients with advanced dementia.

2) To compare the effects of live music therapy, recorded songs, and simulated presence therapy on increasing MATADOC scores and signs of enhanced sense of self

Research Questions

1. What were the MATADOC findings with the participants with moderate and severe dementia?

2. Considering all the collected data including the MATADOC scores, video behavioral/thematic analysis, and the caregiver reports, which condition had a better effect increasing levels of awareness and signs of an enhanced sense of self?

CHAPTER II: LITERATURE REVIEW

The present study explored on the use of the MATADOC with four patients with advanced dementia and evaluated two musical conditions (live music therapy and recorded songs) against one auditory non-musical condition as a control (auditory simulated presence therapy) to increase measures of awareness and signs of enhanced sense of self.

By addressing the pilotage of a reliable and valid music therapy assessment tool for patients with disorders of consciousness (DOC) such as the MATADOC, but with patients with dementia, there were theoretical implications that needed to be properly addressed in this literature review. First. there was a need to characterize the dementia population according to current research, while identifying the diagnostic subtypes that participated in this study, with a context of prevalence and the economic burden that the disease carries. Then, the similarities and differences between the severe stage of dementia (SSD) and DOC were reviewed and identified. Afterward, the fact that the primary organ affected in both conditions is the brain, it required to present an overview of the research on brain and music.

From that point, the study incorporated a theoretical approach of including the research on both DOC and SSD populations, while identifying the research on both musical and non-musical assessment and treatment. This, to increase the theoretical resources for SSD, and to identify the clinical where music therapy attempts to claim a differential benefit. Therefore, each subheading provided selective information to increase the understanding of low responsive patients and the research about auditory and musical processing, musical and non-musical assessments, and musical and non-musical treatments. Finally, there was a need to address the risks of harm of music listening treatments.

Dementia a Neurocognitive Disorder

Dementia is a progressive degenerative disease and a broad term that covers specific acquired brain diseases that primarily affect cognitive function. The DSM-5 has included them in an even broader category called neurocognitive disorders (NCDs). This term encompasses delirium, syndromes of major NCD, mild NCD, and their subtypes. What was usually referred as dementia is now defined as major and minor NCDs, and categorized according to their etiology: NCD due to Alzheimer's disease; vascular NCD; NCD with Lewy bodies; NCD due to Parkinson's disease; frontotemporal NCD; NCD due to traumatic brain injury; NCD due to HIV infection; substance/medication-induced NCD; NCD due to Huntington's disease; NCD due to prion disease; NCD due to another medical condition; NCD due to multiple etiologies; and unspecified NCD (American Psychiatric Association, 2013).

The diagnostic criteria for dementia or major NCD includes 1) evidence of significant cognitive decline from a previous level in one or more cognitive areas (memory, attention, executive function), and based on information provided by a) the individual, a knowledgeable informant, or the clinician, and b) a standardized clinical test; 2) the cognitive deficits negatively affect independence in activities of daily life; 3) the cognitive deficits are not due to delirium, and 4) the cognitive deficits are not explained by another mental illness. The major diagnosis can be specified including the presence or not of behavioral disturbance, and by the severity level: mild, moderate, or severe (American Psychiatric Association, 2013).

Several psychiatric symptoms typically accompany the different forms of dementia. These symptoms range from psychotic symptoms such as hallucinations, paranoia, and delusions; to mood disturbances like depression and anxiety; agitation and combative behaviors; sleep disturbances; apathy; wandering; disinhibition; hyperphagia; hoarding; and other inappropriate behaviors (Jeste, Meeks, Kim, & Zubenko, 2006; Kales, Gitlin, & Lyketsos, 2015). Overall, people with dementia have trouble thinking and communicating because of cognitive deficits in perception, recognition, attention, memory, and degradation of knowledge (MacDonald, Almor, Henderson, Kempler, & Andersen, 2001).

NCD Due to Alzheimer's Disease or Alzheimer's Disease

Alzheimer's Disease (AD) was first described in 1907 by Alois Alzheimer when he published his findings for the case of a 51-year old woman called Auguste Deter. He met her while he was working at the Insane Asylum of Frankfurt am Main. Auguste Deter showed loss of memory, disorientation to time and space, carrying and hiding things, paranoia, hallucinations, confusion, and emotional outbursts. She continued declining until her speech became incomprehensible. She lived five more years, and in the last one, she was mute, incontinent, and immobile in a fetal position. At the post-mortem autopsy, Alois Alzheimer identified three unusual changes in the brain: an atrophic brain with reduced number of neurons, neurofibrillary tangles that used to be neuron cells, and deposits of a peculiar substance throughout the cortex, which today are known as amyloid plaques (Alzheimer, Stelzma, Schnitzlein, & Murtagh, 1995; Graeber & Mehraein,1999). It was not Alois Alzheimer the first to identify the plaques (deposits) and tangles (fibrils), but he was the first one to point to these three changes, and that together occurred in a person with a mental decline such as August Deter (Ingram, 2014).

According to the DSM 5 the criteria for NCD due to AD is the following: 1) The criteria are met for major or mild NCD 2) Insidious onset and gradual progression of impairment in one or more cognitive domains (for major NCD, at least two domains must be impaired), and 3) Criteria are met for either probable or possible Alzheimer's disease. Probable AD is diagnosed if: 1) There is evidence of a causative AD genetic mutation from family history or genetic testing,

2) All three of the following are present: a) Clear evidence of decline in memory and learning and at least one other cognitive domain (based on detailed history or serial neuropsychological testing); b) Steadily progressive, gradual decline in cognition, without extended plateaus; c) No evidence of mixed etiology. Possible AD is diagnosed if there is no evidence of genetic causes (American Psychiatry Association, 2013).

Clinically, there are three subtypes of AD: familial, late on-set, and early on-set. The first one is linked to genes, the second one is classical that occurs after 65 years old, and the third one is acquired before that age (Sahyouni, Verma, & Chen, 2017).

A recent brain study with 225 subjects sub-categorized mild AD in three depending on the predominance of atrophy areas, in parietal, medial temporal, and diffuse. The parietal showed worse cognitive function, while the other two more mild presentations. A combination of medial-temporal damage was characterized by exhibiting impairments in language and executive function (Park et al., 2017). Another way of sub-categorization based on atrophy and sparing is divided into four in either, typical AD, limbic-predominant atrophy, hippocampal-sparing, and no-atrophy (Ferreira et al., 2017).

Several risk factors have been found for AD, like age, family history, less education, head trauma, loneliness, gender, age of mother at individual's birth, having two copies of the type 4 allele of apolipoprotein E, and having mild cognitive impairment (MCI) (Bayles and Tomoeda, 2014).

Aging appears to be the major risk factor, and it is closely followed by genetic factors, which is especially determinant in early-onset AD (Turner, 2003). One of the reasons for aging as a risk factor is that normal aging involves cognitive deficits. One study found that normal aging decreases autobiographical and episodic memory but spared semantic memory. The study compared functional magnetic resonance imaging (fMRI) tests from 15 young and 15 older adults under the retrieval of episodic, autobiographical, semantic memory, and control. They found a loss of specificity activation of brain areas responsible for episodic and autobiographical memory in older adults, but this was not the case for semantic memory and control condition. The researchers concluded pointing to a normal decline of memory that comes with age, evidenced in the loss of ability to represent episodes or their content, and resulting in less richly detailed memories (St-Laurent, Abdi, Burianová, & Grady, 2011).

However, despite AD and increased age, the cognitive function of some individuals has appeared unimpaired. Snowdon (1997) pointed to the fact that Sister Mary within the Nun Study was a woman of 101 years-old with intact cognitive function, but her autopsy showed an increased number of plaques and tangles, typical marks of AD. Her level of education and lack of brain infarcts appeared to have a protective factor in her cognitive level.

Therefore, education has been evidenced as a neuroprotective factor for memory declining and AD. The Religious Order study (n=130) examined a group of clergies annually for memory assessment and brain autopsy after death and identified a relation between years of education and cognitive function. At autopsy, they found that education only modified the relation of neuritic and diffuse plaques, but not for tangles. The interaction between education and the neuritic plaque score was strongest for perceptual speed and weakest for episodic memory. The study found strong evidence to suggest that the relation between senile plaques and the level of the cognitive function differs depending on years of formal education (Bennett et al., 2003).

Both education and bigger brains appear as protective factors for AD. The theory between *brain reserve* and *cognitive reserve* suggests that either having a greater number of neurons within bigger brains, or cognitively enhanced brains through education puts people at a lower risk for dementia. Other forms of cognitive enhancement have been identified and include bilingualism, high participation in leisure activities, and social interaction (Ingram, 2014; Bayles and Tomoeda, 2014).

Sleep has been identified as an important component of health and implicated in AD. Cerebro-spinal fluid is mostly produced at night, and the amount in the interstitial space of neurons increases by 60% when we sleep. Therefore, researchers suggest that sleep might help to remove amyloid beta toxins from the brain by the cerebro-spinal fluid (Mendelsohn & Larrick, 2013; Xie et al., 2013).

The cause of AD is not yet understood, nevertheless, damage to both neurons and glial cells in the brain results in dementia. Factors explaining this damage has been reviewed by Sahyouni, Verma, and Chen (2017) and include misfolding of certain proteins, lack of appropriate brain clearance, decreased neurotransmitters such as acetylcholine, and loss of neurons and synaptic connections. In AD the damage tends to appear first in the hippocampus, and specifically the subgranular zone, impairing the ability to form new memories.

The consensus regarding AD's treatment is about making an early diagnosis. Brain imaging, CSF, blood tests, and genome are currently candidates for biomarkers of AD and dementias (Sahyouni, Verma, & Chen, 2017). Recently, researchers reported that a new blood test can measure levels of protein amyloid-beta and use such levels to predict whether the protein has accumulated in the brain. When combined with age and genetic risk factor, the test was 94% accurate (Washington University School of Medicine, 2019).

Vascular NCD or Vascular Dementia

Vascular dementia (VaD) is caused by injuries to the vessels that supply blood to the brain and could be the second most common form of dementia (Plassman et al., 2007). It is caused by either multiple "micro" strokes, classical stroke, other cerebrovascular diseases, and it can be categorized in acute and sub-acute. Acute VaD occurs after a new onset of an ictal event including large-vessel infarction, poststroke, lacunar, and thalamic dementia, while subacute VaD comprehends Binswanger's Disease or subcortical, and Cerebral Autosomal Dominant Arteriopathy with Subcortical Infarcts and Leukoencephalopathy (CADASIL) (Román, 2003).

The DSM-5 defines the diagnostic criteria for Vascular NCD by two major features, which are characterizing for major or mild NCD and having a vascular etiology. The latter suggested by either the onset related to a cerebrovascular event, the decline in complex attention and frontal-executive function, or an evidence of cerebrovascular disease that accounts for the deficits (American Psychiatric Association, 2013).

Depending on the area of brain damage patients can show loss of planning capacity, working memory, attention, stimuli discrimination, abstraction, conceptual flexibility, and self-control. Because executive function controls volition, planning, programming, and monitoring of complex goal-directed tasks, activities of daily living (ADL) of grooming, dressing, cooking, and shopping, are usually impaired. Other behavioral changes include impulsivity, personality changes, apathy, abulia, and even akinetic mutism (Román, 2003).

Compared with AD, individuals with VaD are likely to have preserved long-term memory, and greater impairment in motor and frontal-executive function (Sachdev & Looi, 2003). Three instruments are usually used to separate the diagnosis: the ischemic score, the pre-stroke dementia interview, and an amnestic form for Mild Cognitive Impairment (Román, 2003).

Frontotemporal NCD or Frontotemporal Dementia

Frontotemporal dementia (FTD) or frontotemporal NCD describes patients that present with behavioral and personality changes and/or changes in expressive behavior. It is sub-categorized in one behavior variant and three language variants; semantic, agrammatic/nonfluent, and logopenic, and subjects can present with any one or more variants (American Psychiatric Association, 2013).

A diagnosis of possible FTD is based solely on the clinical syndrome and aims to identify patients at the mildest stages of the disease. Whereas the diagnosis of probable FTD could be presented when there is evidence of clinical syndrome, plus demonstrable functional decline, and the frontotemporal imaging findings. For the behavioral variant, there must be a decline in social cognition and/or executive function and having three or more of the following symptoms: behavioral disinhibition, apathy or inertia, loss of sympathy or empathy, perseverative, stereotyped or compulsive/ritualistic behavior, hyperorality, and dietary changes. For the language variant prominent decline in language ability, in the form of speech production, word-finding, object naming, grammar, or word comprehension. The criteria also include clinical evidence of relative sparing of learning and memory and perceptual-motor function (Rascovsky et al., 2011; American Psychiatry Association, 2013).

Costs and Prevalence of Dementia or Major NCD

Dementia is a global epidemic and the burden and future impact of dementia has been underestimated, especially for low- and middle-income countries that are more affected. In 2020, more than 50 million people worldwide might be affected by dementia, and it could reach to 75.62 million in 2030, and 135.46 million in 2050 (Prince, Guernchet, & Prina, 2013). In the United States, AD has been estimated to affect somewhere from 2.4 million people (Plassman et al., 2007), to 4.7 million people and this number is projected to nearly triple between 2010 and 2050 (Hebert, Weuve, Scherr, & Evans, 2013).

The global economic burden of dementia was estimated in the US at $604 billion, which is 1% of the global Gross Domestic Product. This cost was estimated considering informal care (unpaid care provided by family and others), social care (community care professionals and residency settings), and direct costs of medical care. At the same time, an increase of 85% in costs has been estimated for the year 2030 (Alzheimer's Disease International, 2010).

The annual cost of this illness has been estimated to be more than $200 billion, with Medicare and Medicaid paying for 68% (Alzheimer's Association, 2015). The total costs of medical and long-term care expenditures for all individuals alive in the US in 2018 that could develop Alzheimer's were projected to be $47.1 trillion (Alzheimer's Association, 2018). Furthermore, Osterberg and Blaschke (2005) found that at least 50% of older adults did not adhere to a regimen of chronic medications, accounting for an estimated $100 billion in preventable costs.

While the potential cost saving for the US population from the early diagnosis of AD could go as high as $7.9 trillion (Alzheimer's Association, 2018). It was estimated that an intervention that delayed the onset of dementia by 5 years, would reduce by 57% the number of people with dementia, and more than $280 billion in Medicare costs (Sperling et al., 2011)

AD is the most common cause of dementia and it accounts for approximately 70% of the cases of dementia, while VaD is supposedly to be the second, accounting for 17.4% of the cases (Plassman, et al., 2007). However, neuropathological studies suggested that mixed dementias could be more common than pure VaD, accounting for up to 45% of the autopsied brains, whereas pure VaD accounted for only 9% to 10% of the cases. FTD has shown to be less common than VaD and could account for 8% to 10% of cases of dementia (Knopman et al., 2001; Schneider, Arvanitakis, Leurgans, and Bennett, 2009).

Relations Between the Severe Stage of Dementia and Disorders of Consciousness

It is well known the relation between Traumatic Brain Injury (TBI), one of the main cause of Disorders of Consciousness (DOC), and the increased risk for the development of dementia (Mendez, 2017). But not much has been said about the inverse causation between dementia and the appearance of DOC.

It appears that the last stage the disease, the severe stage of dementia (SSD), causes loss of the ability to communicate, full-time need for Activities of Daily Life (ADLs), loss of physical capabilities (walking, sitting, swallowing, and control of bowel and bladder), and increased susceptibility to infection (Reed-Guy & Legg, 2016). The extensive brain degeneration might lead ultimately to a loss of self-awareness and overlooking this aspect can be detrimental for patients regarding overburdening, appropriate care, and treatment to follow (Zwijsen, Van der Ploeg, & Hertogh, 2016).

The symptomatology of SSD, especially concerning awareness and consciousness, is very similar to the cases of patients with severe acquired brain injury that fit the label of Disorders of Consciousness (DOC). People with a diagnosis of DOC, either in the vegetative state (VS) or the minimally conscious state (MCS), exhibit poor or no behavioral signs of self or environmental awareness, but are awake and have sufficient preservation of autonomic functions to sustain survival when appropriate supportive care is provided (Posner, Saper, Schiff, & Plum, 2007). These patients are difficult to diagnose and treat and can result in an increased burden of care for families and facilities (Eapen, Georgekutty, Subbarao, Bavishi, & Cifu, 2017).

Even though SSD and DOC have different causes (plaques, tangles, protein malfunction vs. hypoxia, stroke, TBI), their common symptoms of unresponsiveness, unawareness, poor arousal, lack of communication, and need for full assistance in ADLs are virtually the same. At the same time, in both conditions, important brain damage has a severe negative effect on the motor, cognitive, emotional, and social areas of functioning, and the consequent questioning of their level of consciousness.

On the other hand, one of the most important differences between DOC and SSD is that the lack of awareness in patients with dementia is developed gradually instead of suddenly. According to the Global Deterioration Scale (GDS) (Reisberg, Ferris, De Leon, & Crooke, 1982), a level 5 out of 7 is a clear cut of independent function since the patient cannot live on their own without assistance, but it is in level 6 where signs of unawareness start to occur. Memory gets severely impaired resulting in unawareness of recent events and experiences in their lives; people show unawareness of surroundings, time and space; disturbed diurnal rhythm; may become incontinent and unaware of bladder and bowel movements. Whereas patients in stage 7 usually lose all their meaningful verbal abilities and, basic psychomotor skills like walking, and overall, the brain and the body appear disconnected.

Even though the communication of these patients deteriorates progressively as all the other areas of functioning, the description that most dementia scales use is being challenged, since most SSD patients can still produce a form of language. Bayles, Tomoeda, Cruz, and Mahendra (2000) studied the verbal abilities of communication in 49 late-stage AD patients, using the Functional Linguistic Communication Inventory. They found that individuals with bladder incontinence had more communication skills than people with both bowel and bladder incontinence and that ambulatory subjects showed an increased number of words compared to non-ambulatory subjects. The most important finding was that 82% of participants produced language during the evaluation, challenging the description made by most dementia staging scales.

Patients with late-stage dementia can exhibit either muteness, palilalia, echolalia, jargon, or impaired but meaningful communication. Most of the time they state their name and retain aspects of social language. Some could read single words but virtually all of them were unable to express themselves in writing (Bayles & Tomoeda, 2014).

An awareness approach in dementia might improve understating of the SSD, care, and quality of life. Clare, Rowlands, Bruce, Surr, and Downshave (2008) studied signs of awareness in both moderate and severe dementia populations. They studied 80 participants with moderate dementia, and all of them demonstrated a degree of retained awareness expressed in the context of conversations. These demonstrations were categorized to occur in three domains of self, relationships, and the environmental context. In a subsequent study, Clare et al. (2013) found that training staff of a care home to identify signs of awareness was successful to improve the quality of life of the residents with SSD. The rationale behind it was that since the staff identified awareness levels in the patients more accurately, it affected the way they interacted with them, making their interaction more meaningful and consequently improving the patients' quality of life as rated by family members.

Another difference between these two populations is the treatment they usually receive. DOC populations are usually referred to neurorehabilitation, whereas SSD patients could be referred to either nursing homes, palliative care, hospice care, or remain untreated. Nevertheless, a rehabilitation approach could be well used with SSD in terms of maximizing their abilities and strengths. Although restoration of functions may not be possible, the major goal of rehabilitation should be to reduce the impact of dementia on the person's functioning and maximizing the person's potential (Plant, 2002).

For the specific field of music and music therapy, Aldridge (2000) based on his clinical experience identified a common response between coma recovery patients and people with advanced dementia. He proposed that in both cases music connects remaining capacities in a context of joint attention resulting in an improvement of consciousness.

Therefore, based on the following commonalities of symptomatology (poor awareness), main affected organ (brain), level of care (total caregiver dependency), clinical findings, and previous studies using this same conceptual framework (Clare et al., 2012, Clare et al., 2013), in the present thesis SSD is proposed as an eventual form of DOC. This perspective supports the theoretical solution of using the research found for both populations to elaborate this literature review, to evaluate a music therapy assessment tool developed to measure awareness in patients with DOC to patients with SSD, and translate the treatments studied for patients with DOC to SSD. Due to the same reasons, studies with patients with severe brain damage undergoing music listening were also included.

Music and the Brain: A General Overview

From an archeological perspective, the human brain is musical. The fact that musical instruments like bone and ivory flutes were originated at least 35,000 years ago by modern homo sapiens, is not only a sign that music has been with us since long ago but also that our modern brains are wired to create, enjoy and use music (Conard, Malina, & Münzel, 2009). Currently, in the XXIst century, there is growing evidence of the relations between music and areas of the brain that control language, movement, emotions, cognition, and reward. Due to the extensive amount of research in this chapter, mostly recent reviews are presented on each topic, and only a few relevant trials and individual studies were included.

Research in language and music has been a growing field. According to Patel (2003), it has included comparative studies of development, neural plasticity, pitch perception, the cortical representation of speech versus musical sounds, text and tune processing in songs, and the influence of training in one domain on abilities in the other. His research provided a hypothesis for the syntactic overlap between music and language. Based on his own and prior neuroimaging studies, he suggested that linguistic and musical syntax share certain syntactic processes overlapped in frontal brain areas, that apply to different syntactic representations in posterior brain regions. However, a recent review by Schön and Morillon (2018) showed biases in the subtractive methods of these types of studies, questioning the overall validity of their findings. Nevertheless, collecting more recent evidence on music and language they suggested two important links. First, the distinction between music and speech modulation properties could be due to their computational differences since they have different temporal rates. Second, the reverse side of this statement, is that one of the most shared characteristics between music and language acoustic signals is that both have strong temporal constraints, leading to strong temporal predictions.

Another important update in the relation between language and music, is that both hemispheres seem to be involved in speech and music processing, while hemispheric differences appeared to be more quantitative than qualitative. In two experiments of subjects undergoing fMRI during listening of sung words, wordless singing, and spoken words, a bilateral network involving the middle and superior temporal gyri and inferior and middle frontal gyri showed increased activation, while listening to pairs of words that differ in linguistic and musical dimensions, activated the same network although to different degrees. Nevertheless, this was still consistent with previous literature, where the left hemisphere was more strongly involved in speech processing, and the right hemisphere in music processing (Schön et al., 2010).

The review by Schön and Morillon (2018) also presented the evidence that one, music stimulates the dorsal auditory stream much more than language; two, that this pathway is involved in audio-motor transformation and temporal information processing; three, musical training or musical stimulation strengthens the connectivity between auditory and motor cortices; and four, musical training has beneficial effects for speech comprehension, phonological, and reading skills in children.

The predictive component shared in music and language, and the connections observed between music and movement could be at the base of our pleasure and desire to move to the music. Vuust and Witek (2014) presented the predictive coding theory that explains our processing and perception of music in terms of an input against a model. For example, in music, a rhythm (input) is heard in connection to the meter (model), and when the input is compared to the model, the difference is fed forward into the system. Then, a string of computational evaluations at each level of the perceptual hierarchy occurs, from low-level neuronal firing to high-level perception and cognition. Previous experiences affect the predictive model evidencing both bottom-up and top-down processes. Syncopation is evaluated by the balance between prediction and complexity and appears to be dependent on individuals and associated with musical training of the listener. Polyrhythm would be a type of bistable percept in the auditory domain, relying on competition between different predictive models to achieve its perceptually characteristic effect. Lastly, the groove would be achieved through medium degrees of syncopation and an optimal balance between complexity and prediction. Overall, the predictive coding theory can be applied to several parameters in music such as harmony, style, and form.

Rhythm appears to be one of the most readily available prediction elements in music. Beat-based timing is hypothesized to rely on the integration of sensory information with temporal information encoded in motor regions such as the medial premotor cortex. Studies in humans have identified a network of auditory and motor structures involved in the interval- and beat-based timing. Within the cortex, these areas include auditory regions, inferior parietal, premotor, and supplementary areas (supplementary and pre-supplementary motor areas). At the subcortical level, the basal ganglia are thought to be more important for beat-based timing and the cerebellum for interval timing. It is interesting that these motor brain responses appear also during passive listening of rhythms, and not only during active moment as it could be expected (Penhune & Zatorre, 2019).

One of the biological reasons for the organic interaction between auditory and motor areas could be due to the importance of vocal learning in human development. From animal studies, we know that parrots are one of the few animals that show complex motor responses to human music. By bopping their heads and moving their feet to rhythm amongst other movements, researchers suggested they show the same beat-based timing and spontaneity that we see in humans. Parrots, as well as humans, are vocal learners whose brains contain strong auditory-motor connections (Keehn, Iversen, Schulz, & Patel, 2019).

Another important feature of music is related to its effects on emotions. The Musical Mood Induction Procedure (MMIP) is a standard mood induction method used by psychologists, and it has been extensively published in prestigious psychological journals since the '80s (Västfjäll, 2002). The MMIP typically consists of the induction of three types of mood:

depressed, neutral, and elated, but other studies have included the sad/negative, and the happy/positive music induction. In a meta-analysis, MMIP was found to be effective, but not among the most effective mood induction procedures (MIPs), attaining moderate effects when compared to other MIP such as the Velten MIP, which consists on a cognitive effect of repetition of phrases or statements charged with a particular mood content (Westermann, Spies, Stahl, & Hesse, 1996). This limited induction effects could be due to the unwanted effects of cognitive priming, for example when certain music elicits a memory of a past event, or non-music related situations (Sloboda, O'Neill& Ivaldi, 2001). Another limitation of MMIP is that many individual differences affect the emotional responses to music, such as previous musical experience, psychological traits, current states, and contextual features like location and event. At the same time, there appears to be differences between felt emotion versus emotion of the stimuli, between mood and emotion definitions, and the possibility that music might trigger much more emotions than the ones listed on typical research (Scherer & Zentner, as cited in Västfjäll, 2002).

There have been two important attempts to objectify the relationship between music and emotions, one is the Geneva Emotional Music Scales (GEMS) that measures felt emotions from music, and the other one is the BRECVEMA model that attempts to explain the different mechanisms on how music induces emotions. The GEMS is the first instrument devised to measure felt emotions evoked by music. It features 45 emotional states that can be further categorized into nine categories: wonder, transcendence, tenderness, nostalgia, peacefulness, power, joy, tension, and sadness; and three super factors. The researchers developed the 45-, 25-, and the 9-item scale (Zentner, Grandjean, & Scherer, 2008). However, Lykartsys (2013) found reliability issues when trying it for the German population and with broader musical samples besides classical music, suggesting that GEMS-25 is only reliable under the original model. On the other hand, the BRECVEMA model identified eight ways that music can evoke emotions, each one accounting for a letter of the acronym, and they are: Brain stem reflex, Rhythmic entrainment, Evaluative conditioning, Contagion, Visual imagery, Episodic memory, Musical Expectancy, and Aesthetic judgment (Juslin, Harmat, & Eerola, 2014).

The review by Vuileumier et al. (2015) presented the evidence that the combination of widespread activation in motor and cognitive systems, including memory, together with limbic circuits associated with basic dimensions of emotions and reward, are behind subjective music-induced responses. Most interestingly, the GEMS' 9 categories were evaluated under fMRI using samples of classical music representing complex emotions and they found differential responses to each emotion. Furthermore, specific emotion categories sharing similar valence and arousal may be distinguished by their profile of activation in brain regions outside those typically associated with emotion processing, such as cognitive, motor, or even sensory functions. For example, music that evoked feelings of power and triumph elicited stronger activation of motor areas, whereas music that evoked wonder, tenderness, and transcendence involved the hippocampus which is in the core of the brain memory structures. Nevertheless, all the emotions could be reduced and were consistent with prior findings of basic music-evoked emotions and valence. Positive valence correlated with increases in activity in the ventral striatum and ventral tegmental area, corresponding to the well-known dopaminergic reward pathway, as well as the right insula, whereas negative valence correlated with increased activity in the lateral orbitofrontal cortex. Additionally, parametric effects of increasing arousal were observed in several motor areas including motor and premotor cortex, cerebellum, and dorsal basal ganglia (caudate), but also in visual and auditory areas as well as anterior and posterior cingulate cortex involved in attention and alertness. The review finished by presenting the evidence that attention performance can be boosted by pleasant music in healthy people as well as in patients with neurological deficits.

The audition of preferred music appears to activate both the Default Mode network and the reward circuitry. The first one is a group of neurons that become activated while the mind is resting, and is thought to be involved in conscious awareness, self-reflection, autobiographical memories, and emotions. The second one, the reward circuitry, is a basic survival system found in mammals necessary to motivate actions, and it is involved in pleasurable activities and positive reinforcement behaviors (Hodges & Wilkins, 2015; Yinger & Gooding, 2015). The rationale behind these activations comes back to the power of music to entrain extended neural activity through both rhythmic structure and emotional content (Vuileumier et al., 2015).

Lastly, entrainment has been a central component of some recent music therapy techniques to regain motor and verbal function with patients in neurologic rehabilitation. Neurologic Music Therapy (NMT) is an evidence-based treatment model that uses standardized research-based techniques to treat the brain using music and rhythm, and it is currently the most updated and comprehensive model for rehabilitation in music therapy (Thaut, Schleiffers, & Davis,1991; Thaut et al., 2005, Thaut & Hoernberg, 2014). NMT is based on the neuroscience of music perception, music production, and music cognition, and it was developed to rehabilitate patients with neurological disorders such as stroke, Parkinson's Disease, traumatic brain injury, multiple sclerosis, and other neurologic conditions. Currently, NMT covers the three areas of sensory-motor, cognitive, and speech and language rehabilitation.

Auditory Functioning and Processing of Music in Persons with Dementia and DOC

Since music is primarily an auditory stimulus, the studies of both musical and non-musical auditory processing function in subjects with dementia and DOC were reviewed.

Auditory Functioning of Persons with Dementia

Hearing loss increases with age and it has been associated with lower scores in cognitive function in people without dementia, especially on memory and executive function (Lin et al., 2011). Therefore, it is expected that people with dementia would show a higher level of impairment if hearing loss is a co-morbidity. Consequently, the functioning of patients with dementia can improve if hearing loss is compensated with auditory amplification (Allen et al., 2003).

A systematic review found overwhelming evidence of hearing loss as a risk factor for dementia. All the 17 studies reviewed were based on both neuropsychological and audiometric measures. The authors collected three possible reasons: the cognitive load hypothesis, psychosocial hypothesis, and the common-cause or shared neurobiological pathology hypothesis (Thomson, Auduong, Miller, & Gurgel, 2017).

Connected to the common-cause hypothesis, studies have found shared biological pathologies between auditory deficits and dementia. Plaques and tangles have been found in the primary auditory and auditory association cortex in persons with AD (Sinha et al., 1993; Chance et al., 2011). Deficits in auditory habituation were found in patients with familial AD through electrophysiological responses in auditory evoked potentials (AEPs). Subjects with AD showed smaller amplitudes and longer latencies of N100 throughout the habituation test compared to healthy subjects and sporadic AD. The results of the familial AD group evidenced impairment in the primary auditory system, by not adapting appropriately for repeated sensory input (Tarkka et al., 2002).

Central Auditory Dysfunction (CAD), which is the difficulty to understand speech in the presence of background noise, has been suggested as a precursor of AD. A long-term study analyzed audiometric tests from 274 subjects without dementia and followed-up for 4 years. The results showed that severe CAD strongly and significantly predicted the risk of a subsequent diagnosis of AD up to 3 years later (Gates, Anderson, McCurry, Feeney, & Larson, 2011).

Overall, the review by Hardy et al. (2016) showed how poorly understood is the relationship between hearing impairment, dementia, and auditory brain function. The researchers showed differential impaired responses in the auditory modality depending on specific dementia diagnosis and localization of brain damage. For example, typical AD has been associated with difficulties in localization of sounds in busy environments and preserved timbre processing, while AD with Posterior Cortical Atrophy has been associated with increased auditory sensitivity. They pointed to the need to develop reliable tests that can differentiate the effects of peripheral hearing and auditory cognitive dysfunction. From a practical clinical perspective, the researchers recommended to properly assess the hearing of all patients with dementia, through both otological and neurological examination. According to Bayles and Tomoeda (2014), a simple screening of hearing function in people with dementia could be done by administering a basic speech discrimination test, consisting in making them repeat spoken words or judge whether two words are the same.

Emotionally salient auditory stimuli appear to be impaired differently in the subtypes of dementia. A study by Fletcher et al. (2015b) examined pupil dilatation reflex and self-reports of 26 healthy controls and 46 subjects either with AD or any of the three subtypes of FTD (behavioral variant of FTD [bvFTD], semantic dementia [SD], and progressive non-fluent aphasia [PNFA]), undergoing listening of pleasant, neutral, and unpleasant non-verbal sounds. Patients with AD showed retained pupillary reactivity but abnormal coding for the auditory stimuli, tending to rate them more unpleasantly than controls. While subjects with FTD mirrored this response by coding stimuli close to controls but with impaired pupillary reactivity. Overall, only PNFA subjects showed normal coupling between self-reports and normal autonomic pupillary reflex compared to control. Subjects with AD and bvFTD, showed abnormal coupling, and SD patients showed normal coupling, but a distortion of the valence of sounds compared to controls.

Aversion to sounds in AD and a differential response to music in FTD was also found in another study by the same lead researcher and other colleagues (Fletcher et al., 2015a), which is reviewed later under the "auditory processing of music in persons with dementia" subheading.

Auditory Functioning of Persons with DOC

The auditory modality has shown preserved function in patients with DOC both biologically and physiologically. First, a direct path between the amygdala and the thalamus could let a person experience emotion directly from sensory organs and without cortical control (Le Doux as cited in Ghiozzi, 2005). Then, the study by Boly et al. (2004) that measured changes in regional cerebral blood flow of 38 healthy and DOC participants when stimulated with a click sound, found that all patients presented "normal brainstem AEP, showing a preserved function of the auditory periphery to the inferior colliculus" (p.235). According to the authors, these finding suggests residual encoding of basic sound, but without higher-order processing or integration. Kochubeys et al. (2006) also measured AEPs of 33 patients with a diagnosis of vegetative state (VS), and found that N1 amplitude decreased with repetition, evidencing learning and habituation effects. While a change of pitch produced an increase of N1, without reaching significance.

Neuroimages also have identified an increased response through the auditory modality in patients with DOC. Using fMRI Demertzi et al. (2014) consistently observed functioning in the auditory brain network of healthy and comatose patients, 81% of healthy subjects, 46% of patients in Minimally Conscious State (MCS), and 21% of VS patients. The researchers concluded that the auditory network together with the default mode network had the highest accuracy discriminating patients from healthy subjects. This was consistent with a previous review published by Laureys, Perrin, Schnakers, Boly, & Majerus (2005) which showed residual brain function stimulated through the auditory modality in both patients with MCS and VS, with an increased response to emotional stimuli.

Overall, "converging evidence across [neuroimaging and behavioral] both methods support the auditory modality as the most robust and responsive in providing evidence of awareness" in people with DOC (Magee & O'Kelly, 2014, p. 260).

Auditory Processing of Music in Persons with Dementia

Despite auditory disorders, people with AD rarely show difficulties to process music, and many reports show a strong response to music and music therapy in patients from mild to severe stages of dementia (Clair & Memmott, 2008). Nevertheless, Aldridge (2000) recommended testing the hearing capabilities of the patients before initiating the music therapy treatment.

A recent study by Golden et al. (2016) analyzed and compared the auditory processing of music of patients with AD, logopenic aphasia (LPA), progressive non-fluent aphasia (PNFA), and healthy older adults. Through several neuropsychological tests, and after adjusting for working memory performance, they found no specific musical deficits in temporal processing, timbre processing, musical scene analysis, or tune recognition. Nevertheless, both AD an LPA showed group-level deficits of global pitch or melody contour processing, while PNFA showed deficits in both intervals and contour. Therefore, pitch pattern analysis appeared as a common impaired component in the studied patients with dementia. Another finding, although expected, was the evidence that deficits in working memory might amplify musical deficits.

Explicit memory is usually impaired in patients with AD and for the most part, is also affected for melodies. Bartlett, Halpern, and Dowling (1995) published that early AD patients showed difficulties compared to controls undergoing verbal identification of old/new tunes when the music was highly familiar. Nevertheless, a study case by Cuddy and Duffin (2005) showed a devoted music amateur patient with severe dementia due to AD, that still recognized familiar melodies by active music engagement, and errors in melodies and rhythm through non-verbal responses. Consistent with more recent literature, this difference could be due most probably due to music training (Schon & Morillon, 2018).

It appears that patients with SD are more impaired than patients with AD in the recognition of familiar tunes and emotions in music, which is consistent with expectations of milder semantic deficits in AD. In one study that used behavioral and neuroimaging measures, found that the majority of patients with SD were impaired to recognize the familiarity of tunes in comparison to AD patients. However, the 3 out of 13 SD subjects that recognized famous melodies showed more grey volume in the right temporal pole. AD patients, on the other hand, had no differences in grey matter in that area. Overall, this region of the brain differed from the recognition of familiar environmental sounds but overlapped with the recognition of familiar faces. This is consistent with the fact that verbal material is lateralized to the left in most individuals and non-verbal material to the right. In a continuing study, using the same method of both behavioral and neuroimaging measures, the researchers found that although both SD and AD subjects were impaired in labeling emotions in music, SD subjects were more severely impaired, and especially for negative emotions compared to positive. The right temporal pole, amygdala, and insula appeared involved in the labeling of emotions in faces and music, but recognition of emotions in only music involved also the left anterior and inferior temporal lobe, areas that are devoted to the processing of language and verbal semantics. The researchers provided increasing evidence that semantic knowledge impairments are pervasive to different modalities in patients with SD (Hsieh, Hornberger, Piguet, & Hodges, 2012).

However, title identification of songs can dramatically improve in subjects with dementia due to AD, SD, and bvFTD when assisted with options. According to Johnson et al. (2011) AD and bvFTD subjects are less and equally impaired compared to SD subjects that are severely impaired in both title recognition and pitch error identification. In title recognition with assistance, the first ones improved close to healthy control, while SD subjects improved over the previous level of impairment of AD and bvFTD groups before the assistance. Naming familiar songs was correlated with the volume of the left temporal cortex (including left inferior and middle temporal gyri and temporal pole), but also the right inferior temporal gyrus and right inferior frontal gyrus. In contrast, detecting pitch errors in familiar melodies correlated with right temporal lobe structures, including the right inferior and superior temporal gyri and the temporal pole. Altogether, the study provides evidence that the knowledge about the tunes may be intact but the ability to access the verbal labels (titles) may be impaired. The researchers concluded that the detection of pitch errors in familiar melodies may be either bilaterally distributed or perhaps rely somewhat more on the right hemisphere, whereas the naming of familiar melodies may rely on more left hemisphere networks.

Consistent with the prior mentioned studies, the in-depth review of music and hearing in dementia by Johnson and Chow (2015) supports that music processing differs depending on the etiology. AD patients might show preserved music abilities such as playing musical instruments, processing basic aspects of music, and making judgments about familiar melodies, whereas impairment for short-term musical memory tasks. Whereas SD subjects might preserve aspects of music knowledge but may have difficulty processing familiar melodies.

Nevertheless, musical features like tempo and mode could be more relevant than familiarity for a range of specific diagnoses. Regardless of the presence of voice, tempo and mode were recently found to have a significant effect on arousal and mood in subjects with multiple types of dementia from mild to severe. In a recent experimental study, personalized playlists were created to evaluate effects of tempo, mode, and valence of lyrics and its presence, measured by galvanic skin response, facial action units, and reported measures of enjoyment. Slow tempos were more pleasantly reported compared with fast tempos and both increased arousal levels. Major and minor music were associated with expected cultural responses for happiness and sadness. Surprisingly, voice and lyrics did not affect arousal levels or reported levels of enjoyment, which is usually opposed to the response of subjects without dementia (Garrido, Stevens, Chang, Dunne, & Perz, 2018).

Different musical memory systems seem to be preserved in AD according to a recent review by Groussard, Chan, Coppalle, and Platel (2019). The most consistent system found across all the dementia stages was musical semantic memory, followed by both anterograde and retrograde semantic memory encoding, therefore researchers recommended using these functions for therapeutic purposes. Regarding episodic musical memory, even though it appeared more impaired, researchers pointed to the lack of current understanding of the different stages of memory construction, such as encoding, storage, or retrieval, and recommended that future studies could address this issue.

One of the most outstanding responses to music in a few patients with dementia is the development of musicophilia, an abnormal craving for music usually associated with focal degeneration of temporal lobes. A study published by Fletcher, Downey, Witoonpanich, and Warren (2013) compared two groups of 12 musicophilic subjects with 25 non-musicophilic subjects. All the musicophilic subjects were diagnosed with FTD NCD, but the SD type was more represented than the bvFTD. Under the scanner the musicophilic group presented significantly increased gray matter in the left posterior hippocampus, and (less robustly) a distributed network of additional areas including parahippocampal, temporoparietal, anterior cingulate, and prefrontal cortices; and with atrophy of gray matter in posterior parietal and orbitofrontal cortices. The researchers stated that musicophilia is part of a much wider repertoire of abnormal behaviors that emerge in FTD.

In a posterior study, Fletcher et al. (2015a) analyzed auditory hedonic phenotypes reported in both AD and FTD subjects and compared them with FTD and AD subjects without auditory hedonic reports, and healthy subjects. Either music aversion, aversion to sounds, or musicophilia was highly observed in patients with FTD and infrequent in subjects with PNFA, and highly correlated with certain genetic mutations involved in the production of tau protein like MAPT, followed by C9orf72 mutation. Both of genetic subgroups showed more aversion to sounds. Aversion to sounds was the exclusive auditory phenotype in AD, whereas musicophilia was more common in both bvFTD and SD. Only one patient with SD developed an increased liking for environmental sounds. Auditory hedonic alterations correlated with grey matter loss in a common, distributed, right-lateralized network including the anteromedial temporal lobe, insula, anterior cingulate and nucleus accumbens. In conclusion, musicophilia is associated with genetic mutation and FTD with right-lateralized brain degeneration.

Auditory Processing of Music in Persons with DOC

Autonomic response associated with emotional values has been found in patients with DOC undergoing music listening of classical compositions. Riganello, Candelieri, Quintieri, Conforti, and Dolce (2010) performed a data-mining study and found that both groups of healthy (n=16) and patients with VS (n=9) showed autonomic responses to symphonic music composed by Mussorgsky, Tchaikovsky, Boccherini, and Grieg. The responses were measured by analyzing the 'normalized units of Low Frequency' (nu_LF) of the Heart Rate Variability variable. Due to the evidence that "too high and too low values of nu_LF are related to emotional values" (Riganello et al., 2015, p.5), suggested that these changes might reflect emotional processing of the stimuli on residual auditory function. Another study performed by almost the same researchers (Riganello, Cortese, Arcuri, Quintieri, & Dolce, 2015) but the same sample, suggested that simpler music might be easier to process in patients with DOC. This time analyzing another variable, Sample Entropy, they found no significant differences between groups and controls, suggesting similar processing of the emotional stimuli. The nu_LF was found significant between groups in favor of Grieg and Mussorgsky, and Sample Entropy only for Mussorgsky. Amongst the VS group, they also found significant effects between Mussorgsky and Boccherini for the Sample Entropy variable. In sum, these findings suggest that "the autonomic response was characterized by decreasing values in nu_LF and Sample Entropy in VS, when the musical complexity was higher" (p.5) measured by the Formal Complexity and General Dynamics parameters.

Preferred music listening appears to have effects on auditory networks implied in rhythm, music perception, and cerebral regions linked to awareness and autobiographical memory in patients with DOC. Heine et al. (2015) studied healthy and DOC patients going under fMRI while they listened to preferred music and control (noisy environment of the scanner). The order was randomized, and three networks linked to conscious sound perception were assessed for functional connectivity: internal/default mode, auditory, and external network. In general, patients showed significantly limited functional correlations with the primary auditory cortices. However, they found larger areas of functional connectivity for all patients with DOC undergoing music listening, which was not found at all in the healthy group. As expected, both auditory and external networks showed increased responses under the music condition, being significant in the primary auditory cortex. These increases were found in the bilateral precentral gyrus (stronger on the left), left frontal pole, and the left dorsolateral prefrontal cortex for the auditory network; while middle temporal, frontal eye field, supramarginal/angular gyrus, and the temporoparietal junction for the external network. The researchers suggested the need for integration of primary cortices and higher-order areas to reach consciousness. Put differently, unconsciousness might be related to a disruption in feedback processing to the auditory regions.

DOC studies have identified that auditory stimulus with personal and/or emotional meaning like preferred music produces meaningful results compared to unrelated auditory stimuli (O'Kelly et al., 2013; Magee et al., 2014; Okumura et al., 2014; Heine et al., 2015).

Assessment

Non-Musical Assessment Tools for Patients with SSD

In general terms, the assessment of patients with dementia follows general principles. From a psychological perspective, the assessor should have a thorough knowledge of the tools used and awareness of common co-morbidity. From a neurological perspective careful examination of history, neurologic evaluation, ancillary tests, and knowledge of types of dementia provides an accurate diagnosis; and a correct diagnosis is essential for accurate prognosis and treatment. Finally, from a psychiatric perspective, psychiatric complications of dementia are often the major contributor to disability, patient and family distress, and costs of care; differential diagnosis should always include underlying medical illnesses, which might be contributing to behavior change; and psychiatric symptoms may change over the course of the patient's illness (Lichtenberg, Murman, & Mellow, 2003).

According to Sheehan (2012) dementia assessment scales cover a wide range of areas such as cognition, function, behavior, quality of life, depression, caregiver burden, and overall dementia severity. However, most of them are not validated or do not work well with patients with SSD. The exceptions are the scales that track overall dementia severity such as the Clinical Dementia Rating (CDR) (Morris, 1993), Functional Assessment Stages (FAST) (Reisberg et al., 1984), and Global Deterioration Scale (GDS) (Reisberg, Ferris, de Leon, & Crooke, 1982), and recently, quality of life scales that allow proxy rating.

Also, current tools could be not sensitive enough to capture preserved functioning in patients with dementia. For example, according to Sabat (as cited by Power, 2010), AD usually spares the prefrontal cortex, allowing the people to behave in a socially sensitive way, and this is usually not tracked by most of the scales. Many cognitive abilities are, therefore, well preserved and are not currently assessed by typical cognitive assessment tools. The ability to experience pride and maintain dignity, shame, and embarrassment, feeling concern for others, communicating feelings with assistance or with non-verbal aids, maintaining self-esteem, and showing spiritual awareness, are only a few maintained abilities observed in this population, in addition to more complex behaviors such as displays of love, affection, friendship, and humor.

Fortunately, two recent tools have been developed specifically for SSD patients: the AwareCare and the GATOS questionnaire. The AwareCare (Clare et al., 2012) is a tool developed to identify signs of awareness in patients with SSD and it was based in the Wessex Head Injury Matrix used to measure awareness in patients with DOC. It consists of 10 different stimuli and 14 possible categories of responses. The stimuli were the following: someone nearby, the resident is touched, the resident is spoken to, talking nearby, loud noise, object nearby, food or drink introduced, call by name, take the hand, and introduce an object. In the study, 40 residents were observed, and all participants showed awareness to varying degrees, while social stimuli elicited the greater responses. Greater awareness was associated with better cognitive function, self-care, mobility, and responsiveness, but not with the proxy-rated quality of life.

The GATOS questionnaire or Gatos Clinical Test (GCT) (Tsoucalas et al., 2015) is a reliable and validated tool to assess patients with End-Stage Dementia with scores from 0 to 2 in Mini-Mental State Examination (MMSE) and aims to identify those patients who could sustain some quality of life. The questionnaire consists of three subscales "Autonomy/Alertness", "Gnosias" and "Somatokinetic function", 14 closed type questions rated on a Likert scale, and a total score that is used to evaluate patient's dementia. Patients with a GCT total score of less than 12.5 had a 75% probability to have zero MMSE score.

Non-Musical Assessment Tools for Patients with DOC

According to Jennett and Plum (1972), "the limits of consciousness are hard to define satisfactorily and we can only infer the self-awareness of others by their appearance and their acts (p.3). Therefore, the tools to assess this population usually rely on observational methods within 7 domains: sleep-wake cycles, awareness, motor skills, auditory function, visual function, communication, and emotional integrity (Giacino et al., 2002). There is an estimated number of 40% subjects within this population that could be misdiagnosed, the reason why accurate diagnosis requires the skills of a multidisciplinary team experienced in the management of people with complex disabilities (Andrews, Murphy, Munday, & Littlewood, 1996). This number of misdiagnoses has been consistently confirmed (Monti, Laureys, & Owen, 2010).

More than 13 scales have been developed with significant measures of validity and reliability. Seel et al. (2010) identified the Coma Recovery Scale Revisited (CRS-R) as the best assessment tool with this population and it may be used to assess DOC subjects with minor reservations. Eapen et al. (2017) confirmed the CRS-R as the gold standard for diagnosis of DOC patients but added that advanced neuroimaging and electrophysiological techniques presented possibilities for improvement of the current diagnostic classification systems. This is consistent with the study published by Monti et al., (2010) where 5 out of 54 DOC subjects presented willful modulation of brain activation measured by fMRI.

Music Therapy Assessment Tools for Patients with Dementia

The firsts efforts to elaborate assessment tools for patients with dementia through music goes back to the 90s. Four attempts were pursued by then to assess engagement and emotional expression (Gaebler & Hamsley, 1991), to assess psychological, physical, and social patterns (Glynn, 1992), residual musical skills (York, 1994), and performance of musical tasks (Lipe, 1995). The first two evaluated behavioral responses of patients with dementia through recorded music, while the other two evaluated musical reactions and responses of people with dementia during musical tasks.

Later, Hintz (2000) presented a comprehensive geriatric assessment tool with 10 areas of information: biographical, cognitive, memory, social, emotional, motor, sensory, musical, clinical impressions, and recommendations. The assessment tool evaluated 5 different sets of skills: motor, cognition, behavioral/psychosocial, expressive and receptive musical skills, and gave freedom to elaborate on the musical experiences that the music therapist considered. The score served the function to define the placement of individuals in different music programs

Later, Munk-Madsen (2001) presented a protocol for assessment, not an instrument, and to be implemented during 3 or 4 sessions with a patient with dementia. It consisted of 6 items with sub-questions of musical activities, motor activities and quality, emotional level, cognition, and mental activity, attention and contact, and the client's comments/reactions to the music therapy session.

After that, no instruments were developed but Aldridge (2000) proposed improvised music as an ideal medium to assess areas not covered by traditional test instruments, such as fluency, perseverance in context, attention, concentration, and intentionality.

Fairly recently, the Music in Dementia Assessment Scales (MiDAS) was developed to measure changes in the wellbeing of patients participating in music therapy sessions. It consists of the five Visual Analogue Scale items: levels of Interest, Response, Initiation, Involvement and Enjoyment, and a supplementary checklist of notable positive and negative reactions. The way it was developed through a focus group, long-table approach, peer and expert consultation, field-testing, and the evaluation of the items, gives to MiDAS strong content validity. In the following study, McDermott, Orgeta, Ridder, and Orrell (2014) studied the psychometric properties of the instrument analyzing a total of 629 (staff = 306, therapist = 323) MiDAS forms. The statistical analysis revealed that MiDAS has high therapist inter-rater reliability, low staff inter-rater reliability, adequate staff test-retest reliability, adequate concurrent validity, and good construct validity. Also, showed no ceiling effects and confirmed its validity with patients across stages.

Recently, Tan et al., (2018) published the validation of the Music Therapy Engagement scale for Dementia (MTED), which as its name says, was developed to assess the level of engagement in music therapy. Content validity was attained through iterative consultations, trial sessions, and revisions. The final five-item of the scale assessed music and non-music related elements. Psychometric properties were evaluated with a group of 62 subjects with dementia, resulting in good internal consistency, good inter-rater reliability, and good construct validity. The MTED total score correlated strongly with the combined items comprising Pleasure, Interest, Sadness, and Sustained attention of the Greater Cincinnati Chapter Well-being Observation Tool. The excellent inter-rater reliability demonstrated that MTED could be understood and used by a person with a minimal musical background. Overall, the scale showed excellent psychometric properties to measure both music and socio-emotional engagement of persons with dementia during music therapy. Since McDermott et al. (2014) also obtained a one-factor solution and similar factor loadings in their validation study for MiDAS, researchers suggest that engagement during music therapy may be a uni-dimensional construct.

Music Therapy Assessment Tool for Patients with DOC

The first study that suggested that comatose patients could be assessed with music comes back to Boyle and Greer (1983). They found increased motor responses with contingent music as a reward on VS patients: "The most important contribution of this experiment is the finding that experimental analysis procedures may expand the assessment of the comatose patient" (p.11).

Over twenty years later a study by Magee (2005) stated to have found an improved and differential diagnosis between VS and MCS through music evaluation. The researcher presented a case of a patient whose VS diagnosis changed to MCS after showing purposeful responses to the music assessment. Based on these findings, Magee developed the first assessment tool to measure awareness with low awareness patients. It took place in the Royal Hospital for Neuro-disability in London, and it was named the Music Therapy Assessment Tool for Low Awareness

States (MATLAS) (Magee, 2007). It consisted of 14 items that assessed five domains: motor responses, communication, arousal, auditory and visual responsiveness. Through changes in the live music presented and attending to the patient´s behaviors contingent to changes in the parameters of sound and music, it was possible to elaborate a detailed report of the patient's responsiveness to their auditory environment. Overall, the scale intended to identify musical responses indicating awareness in a way that other scales could not account, such as tapping a finger to the beat, or a vocal sound matching the pitch of the music. Daveson (2010) studied the assessment of 33 MATLAS with patients that were thought to be in Low Awareness State and found differences in the length of assessment time between VS patients and MCS patients.

Afterward, O'Kelly and Magee (2013b) improved the scale and changed its name to the Music Assessment Tool for Awareness in Disorders of Consciousness (MATADOC) using the more current name for this population (Gosseries et al., 2011). The scale was then formed by three subscales, where the principal subscale gave the diagnostic information through 5 items: responses to visual stimuli, responses to auditory stimuli, awareness of musical stimuli, verbal commands, and arousal. The second subscale provided relevant information to the music therapist and for the environmental management of the patient through 2 items: responses to music (observable behaviors in the patient contingent to musical stimuli), and musical response (identification of musical parameters that trigger a change in behavior). Lastly, the third subscale provided clinical information to inform goals and clinical care through 7 items: non-verbal communication, vocalization, motor, intentional behavior, attention to task, emotional response, and choice-making (Magee et al., 2014).

Using five years of medical records from 42 patients, the researchers compared MATADOC with the SMART, a popular scale used with DOC patients, and found a high agreement between the two scales, but with different sensitivity. MATADOC showed higher scores on auditory and visual domains, while SMART showed higher scores on the motor domain. They concluded that both assessments used in combination provided unique information predictive of a patient's awareness (O'Kelly & Magee, 2013b).

Researchers measured the psychometric characteristics of the three subscales. First, Magee, Siegert, Daveson, Lenton-Smith, & Taylor (2014) measured psychometric characteristics of the principal subscale and found 100% agreement with the SMART scale, with a cohort of 21 subjects with DOC. The five items showed satisfactory internal reliability and a strong first principal component, confirming the MATADOC Principal Subscale as a robust uni-dimensional and homogenous subscale for assessing awareness in patients with DOC. The importance of the first subscale is that it is the only one with a diagnostic utility. Later, Magee, Siegert, Taylor, Daveson, & Lenton-Smith (2016) measured psychometric characteristics of the subscales two and three, finding mixed results. Four items showed 'adequate' Inter-Rater Reliability (IRR) and Test-Retest Reliability (TRR), two other reached just below the line for 'adequate', and other three items were poorly scored: 'choice-making' showed poor IRR, 'musical response' both poor IRR and TRR, and 'behavioral response' poor consistency with 'musical response' item. These differences were discussed in terms of scoring, assessor experience, and MATADOC training. The variability for 'choice-making' might be rooted in the inability of VS patients to communicate, and it is, therefore, an item pertinent to the MCS patients. Overall, the results for subscales two and three point to a work in progress, nevertheless they do not have diagnostic value and mostly provide important information for staff and music therapy treatment.

Currently, the MATADOC is expanding to the pediatric DOC population. Magee, Ghetti, and Moyer (2015) conducted experimental research comparing DOC with other traditional scales with positive, but limited results. Other avenues that the MATADOC is currently exploring are further validation of MATADOC with the DOC gold standard CRS-R (Seel et al., 2010), testing MATADOC for related populations (pediatric DOC, end-stage dementia, and delirium), inclusion of MATADOC in wider research studies, and translation into other languages (Magee, 2018).

Recently, another music therapy assessment tool for DOC patients was developed by Binzer, Schmidt, Timmermann, Jocheim, and Bender (2016) called MUVES, which is a German acronym that translated would be Music Therapy in a Vegetative or Minimally Conscious State, and it was created for video analysis. They studied three conditions: during, before, and after Individual Dialogic Music Therapy (IDMT). IDMT is a live improvisation technique for patients with DOC. It consists of improvised music played or sung by the music therapist, which includes changes influenced by all noticeable reactions of the patient, allowing them to establish a non-verbal dialogue between therapist and patient. The scale was formed by 6 subscales that measure: auditory, visual, motor functions, oral functions, communication, and vigilance. The lowest scores appeared after IDMT when patients were relaxed or sleeping, suggesting common fatigue after activation of the patients. Although a small sample of three subjects, the researchers found acceptable IRR between the three conditions and significant correlations with almost all items of the CRS-R. MCS patients responded more to IDMT than VS patients, but not as much as it would be expected. This was probably due to the low participant number, but also showing that VS patients respond considerably to IDMT. Overall, the differences with the MATADOC are the use of music improvisation in response to subtle signs of awareness of the patient instead of musical stimuli, and an open non-predetermined procedure instead of a standardized protocol.

In addition to musical assessments, neuroimages could show the effects of music therapy interventions in the rehabilitation of DOC patients. Lord and Opacka-Juffry (2016) suggest the application of the mesocircuit and thalamocortical connectivity models using electroencephalography (EEG) coherence measures to assess better consciousness during music therapy research.

Treatment

Pharmacological Treatment for Patients with SSD and DOC

In patients with SSD, both anticholinesterase drugs and memantine are approved by the Food and Drug Administration. Anticholinesterase drugs like donepezil, rivastigmine, and galantamine, work by enhancing the availability of acetylcholine in the synaptic space by inhibiting the enzymes that break down it. The most popular of these drugs is donepezil. It enhances memory for some time, but it does not prevent the progression of brain degeneration, as neurons that produce acetylcholine continuously die (Ingram, 2014).

Memantine is another class of medications used in AD. It is called the N-methyl-D-aspartate receptor or NMDA receptor and prevents a decline in learning and memory. NMDA receptors work controlling glutamate levels that when in excess are associated with neuron death. VaD is usually treated through anti-stroke medication and management of risk factors, such as hypertension, atrial fibrillation, diabetes, and high cholesterol. Whereas FTD does not have approved drugs yet to treat or prevent the disease, and only antidepressants, sedatives, and other drugs used in AD and Parkinson´s Disease may help to manage behavioral and cognitive problems (National Institutes of Health, 2017).

Overall, pharmacological treatments have shown both weak and negative effects in the treatment of behavioral symptoms in patients with dementia (Schneider, Dagerman, & Insel, 2006; Karlawish, 2006). On top of that, it appears that overmedication of prescription medicine could be affecting and decreasing levels of functioning in ADLs in patients with dementia (Sakakibara, Igarashi, Takase, Kamei, & Nabeshima, 2015).

When it comes to pharmacological treatment with DOC populations, there are currently no international guidelines in this regard. However, pharmacological treatments like zolpidem (a non-benzodiazepine hypnotic that potentiates GABAA receptors) had shown small effects improving behavioral responsiveness in few patients with DOC (Thonnard et al., 2014). Dopaminergic agents have been also used to stimulate DOC and brain injury patients, such as levodopa, bromocriptine, amantadine, and apomorphine, showing some positive effects. However, there is still a need for further exploration of these drugs, and to determine which treatment would provide a better neurological outcome in relation with patient's etiology, diagnosis, time since injury, and overall condition (Zafonte, Lexell, Cullen, 2000, 2001; Gosseries et al., 2014).

Non-Pharmacological Treatment and Approaches for People with Dementia

Reality orientation therapy (ROT) is an early non-pharmacological approach that was developed in the 50s as a response to confused people with dementia. It consists of reorienting the person through continuous stimulation connected to their environment. With time, it became associated with rigidness and confrontation, and lead to a decreased use of it. However, Metitieri et al. (2001) analyzed the effects of 74 patients that underwent either intensive or weak ROT and found that in early to middle stages of dementia it may delay nursing home placement and slow down the progression of cognitive decline. In a recent meta-analysis published by Chiu, Chen, Chen, and Huang (2018) ROT found an overall random effect of reality orientation therapy on improving cognition, but not on behavioral symptoms of depression. The researchers recommended dosage of 600 minutes of ROT, but this hypothesis has not been confirmed yet.

Reminiscence therapy (RT) is a cognitive stimulation for patients with dementia that consists of discussing and sharing memories using prompts to trigger conversation and recall. It started in the 70s and is widely used in many formats. Three reviews have studied the effects of RT, in 1998, 2005, and recently in 2018. The last one analyzed a total of 22 RCT studies. They found that effects may vary depending on the location that it takes place, in-care homes vs. community, but overall, there is evidence that RT can improve quality of life, cognition, communication, and possibly mood in people with dementia, although benefits were small. Unfortunately, studies that compared to music therapy were not included in the review (Woods, O'Philbin, Farrell, Spector, & Orrell, 2018).

Overall, cognitive stimulation, which includes both RO and RT, between other modalities, have shown positive effects above any medication on people with mild to moderate dementia, but not for patients with SSD. According to a Cochrane Review by Woods, Aguirre, Spector, and Orrell (2012) improved cognitive function was evident within 1 to 3 months follow-up, and it did not affect mood, ADLs, or behavioral symptoms. Activities reviewed included discussion of past and present events and topics of interest, word games, puzzles, music, and practical activities such as baking or indoor gardening. The authors concluded that patients with SSD were not appropriate for cognitive stimulation (Woods, Aguirre, Spector, & Orrell, 2012).

The type of care has shown to be the primary way to control symptoms in patients with dementia across stages. In their own homes, two negative extremes can be usually found, one is the lack of response to their needs, and the other is excessive assistance that fosters dependence. A third one is related to the type of assistance they get or not when they go through major changes. As people with dementia do not cope well with change, they can behave inappropriately in any circumstance of these characteristics such as illnesses, admission to hospitals, or nursing homes (Jolley, 2005)

Assisted living facilities and nursing homes use different techniques to take care of patients with dementia and prevent behavioral and physiological symptoms. According to Mayo Clinic (2019), any caregiver of a patient with dementia should consider the following tips to reduce the patient's frustration, the caregiver should establish a routine, take time and anticipate that tasks may take longer, involve the person with cues if needed, provide choices, give one-step instructions, limit napping of patients, and reduce distractions. To reduce risks of falls and accidents, it is recommended to create a safe environment, and focus on individualized care by having patience and flexibility.

In hospice care, therapeutic strategies with SSD patients include maintaining the dignity of patient and caregiver, preventing an excess of disability, maximizing function, comfort, and quality of life. Interventions are based on the patient's preferences, abilities, and usual pattern of response; working on the environment to maximize safety and autonomy, and identify triggers of behavioral symptoms, such as fatigue, multiple stimuli, hunger, need to eliminate, changes in routine, and excess of demands (Volicer & Hurley, 1998).

This is consistent with the disability and person-centered care approach, which was a major shift from the bio-medical model and the over-burden on patients with dementia. Kitwood (1990) challenged the bio-medical model and stood against a deterministic view that neurologic impairments accounted for all the deficits of persons with dementia. He stated that psycho-social factors interplay with neurological deficits impairing the personhood of the individual. He defined an equation that senile dementia is the compound result of neurologic impairment plus malignant social psychology. This malignant social psychology is a deceiving and inappropriate way that people use when treating people with dementia. He specifically described how people use treachery, disempowerment, infantilization, intimidation, labeling, stigmatization, outpacing, invalidation, banishment, and objectification, and consequently debilitating the personhood of the dementia sufferer. Even though there are no bad intentions, this social psychology is malignant because of its negative effects upon the people with dementia. Additionally, he pointed to the inadequate preparation of society and those who are working with confused elderly people. Therefore, he suggested that by improving social psychology knowledge, dementias could be arrested or even reversed to some degree. Later, Kitwood (1997) developed a model of psychological needs to be fulfilled for people with dementia. These needs act like a cluster rather than a hierarchy and are closely interconnected. The diagram consists of a flower, with love in the center as an all-encompassing need, and with five petals around the center showing the needs for comfort, attachment, inclusion, occupation, and identity. This model defined the principles of the person-centered model of care for people with dementia.

Mary Marshall in consonance with Kitwood put together the concept of rehabilitation on patients with dementia. She presented four approaches to this concept, but two of them are particularly interesting. One approach is cognitive rehabilitation, where the goal is to increase the use of healthy areas, rather than assuming the inevitability of the cognitive decline. The other is the one that stresses the need for proactive and positive interactions, as most people can function better if they receive appropriate help. She highlighted that to rehabilitate patients with dementia there are key areas that need to be addressed such as: working within the teamwork, working with families, adding prostheses (aids, adaptations, tools), removing causes of excess or unnecessary disability, identify individual learning and motivation factors, and focus on specific aspects of the person's life (Marshall, 2005).

Validation therapy (Feil, 1993) is one of the first approaches that moved away from the cognitive abilities of people with dementia and moved towards their feelings, experiences, and emotions. Feil covered the different stages of patients with dementia, and developed strategies to enhance communication with people on the SSD, when they were confused, agitated, and even non-verbal. Only one systematic review analyzed the RCTs evidence for validation therapy, and 2 out of 3 showed significant effects of validation therapy, however, the evidence is still insufficient (Neal & Barton Wright, 2009).

The Best Friends™ Approach founded by Bell & Troxell (1997) is another non-pharmacological treatment or a way to approach people with dementia that shares similarities with validation therapy, and it is also appropriate with SSD. It is a relational approach guided by the figure of friends and what they are and do, such as know each other's history and personality, do things together, communicate, build self-esteem, laugh often, be equals, and work at the relationship.

Another therapeutic component of care that has been studied to be effective with patients with SSD is therapeutic touch. Hatfield and McClune (2002) found that in patients with dementia touch has to be intentional, otherwise, it may not be acknowledged, or it could trigger irritation or annoyance. They recommended exploring a balance between gentle and intentional with each patient individually. According to a recent meta-analysis, the inclusion of touch showed effects on decreasing aggressive behavior in patients with dementia, but it did not improve the overall scores of anger, sadness, or anxieties (Wu, Wang, & Wang, 2017).

According to Bayles and Tomoeda (2014) to improve the success of therapeutic interventions with people with dementia the principles of neuroplasticity have to be considered by increasing attention, reward, emotional involvement, and stimulation through priming, active engagement, and elaborate encoding. At the same time, the perceptibility of stimuli (visual and auditory), span capacity of working memory, and task complexity should be considered and addressed. Regarding this last one, reading of words appeared as the least complex communication task (Bayles, Tomoeda, Kaszniak, & Trosset, 1991). Bayles and Tomoeda (2014) indicated more considerations for successful treatment interventions for people with dementia, and they included minimizing error responses, considering that recognition is easier than recall, use retrieval cues that reflect support given at encoding, allow more time to respond, and avoid having client multitask.

Power (2010) advocated for interventions that could target the environment, be engaging, individualized, and boost the self-esteem of the person with dementia. At the same time, he criticized that non-pharmacological studies tended to compare individual variables (such as music therapy), which is against an experiential approach that usually requires multiple interventions concurrently. He identified this individualistic aspect as an influence of the biomedical approach in research.

Sensory stimulation (SS) has recently been found to be equally effective compared to personalized music in the management of psychological and behavioral symptoms in patients with severe dementia. Maseda et al. (2018) published an RCT with 21 subjects undergoing either a multisensory stimulation environment (MSSE) in a Snoezelen room or listening to preferred music through speakers. Both groups showed significant changes in mood and behavior scores and vital autonomic responses by increasing oxygen saturation and decreasing heart rate. The

MSSE group performed better follow-up to stimuli, and the music group was more relaxed and happier.

A recent review of reviews of non-pharmacological treatment for patients with dementia found music, sensory stimulation, simulated presence therapy, and validation therapy to have the strongest evidence to reduce behavioral symptoms. Exercise and light therapy improved or maintained ADLs, while cognitive stimulation and RT improved cognition. The strongest evidence for reducing emotional disorders was music, psychological interventions, and RT. (Meyer & O'Keefe, 2018).

Recent Relevant Data on Non-Pharmacological Prevention in Early Dementia

To suggest the feasibility of a music therapy treatment with patients with SSD in the current scientific context, there is a need to review the updated and growing amount of new big data evidence in the prevention and early treatment in patients with dementia. This is especially true since there is evidence of long-term brain degeneration before symptoms appear, whereas the demographic trend of dementia decline in higher-income countries suggests that there could be a way to prevent it (The National Academies of Sciences, Engineering, and Medicine, 2017).

A first systematic review published by the Agency for Healthcare Research and Quantity (AHRQ), that examined a total of 25 systematic reviews and 250 primary research studies, concluded that there was not enough information to make a recommendation to prevent cognitive decline and dementia, mainly because of limited and low-quality evidence of data. Nevertheless, some factors were found to be associated with increased risk of AD and cognitive decline, such as diabetes, epsilon 4 allele of the apolipoprotein E gene (APOE e4), smoking, and depression. While factors showing a consistent association with decreased risk of AD and cognitive decline were cognitive engagement and physical activities (Williams, Plassman, Burke, & Benjamin, 2010).

The second and most recent systematic review by the AHRQ considering RCTs found no enough evidence for interventions preventing or delaying Age-Related Cognitive Decline (ARCD), Mild Cognitive Impairment (MCI), or Clinical Alzheimer´s-Type of Dementia (CATD). Nevertheless, the study found weak to moderate evidence of benefit in three types of intervention: cognitive training, blood pressure management in people with hypertension, and increased physical activity, and therefore, considered them as priorities of research. It also identified areas to improve in future research: identify individuals who are at higher risk and tailor interventions accordingly, increase participation of underrepresented populations, begin with younger participants and have larger follow-up periods, use consistent cognitive outcomes measures across trials, integrate robust cognitive outcome measures into trials with other primary purposes, include biomarkers as intermediate outcomes, and conduct large trials designed to test the effectiveness of an intervention. Finally, they developed important areas for research and to determine their effectiveness: new anti-dementia treatment, diabetes treatment, depression treatment, dietary interventions, lipid-lowering treatments, sleep quality interventions, social engagement interventions, and vitamin B12 plus folic acid supplementation (Kane et al., 2017).

In the AHRQ systematic review (Kane et al., 2017) the most important intervention that showed sustained positive effect of cognitive stimulation was the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) approach. Outcomes included long-term benefits in reasoning, speed of training, and maintenance of independence in independent ADLs in older adults with normal cognition. Some other studies showed improvements in at least one domain, but transfer effects to other areas were rare. One study examined the effects of the ACTIVE approach in the incidence of dementia. This was a large randomized controlled trial (RCT) (n=2,802), that found that with 2 hours weekly during 5 to 6 weeks, cognitive training did not affect rates of incident dementia after 5 years of follow-up (Unverzagt et al., 2012). There is extensive evidence of improvement of performance after training a single task, but more evidence is needed to point towards long-term benefits, and transference from one domain to another, such as improvement on general ADLs (Simons et al., 2016). In conclusion, the AHRQ systematic review identified 4 main points regarding cognitive training: it can delay or slow ARCD; there are no current RCT evidence that it can prevent, delay, or slow MCI or CATD; and there is no evidence that it can be transferred to computer-based "brain" training, maybe because they lack the social engagement component. Mostly, the same encouraging but inconclusive evidence was applied to physical activity (Kane et al., 2017).

The Academies of Sciences, Engineering, and Medicine (2017) pointed to some considerations with multimodal approaches, optimal dose, and adherence. First, multimodal approaches may be more effective than single-component interventions. Probably, because they resemble more the real world where individuals must deal with the use of different skills. Second, it is unclear which component (dose, delivery schedule, intervention duration, and timing) might be affecting the results of interventions. Third, as Osterberg and Blaschke (2005) found, at least 50% of older adults did not adhere to a regimen of chronic medications. Therefore, identifying multimodal therapies that could enhance adherence to treatment becomes a major aspect of preventing cognitive decline.

Multimodal approaches are currently promising treatments with patients with early dementia. Since a study case showed that 9 out of 10 patients with acquired cognitive deficits due to either AD, MCI, or subjective cognitive impairment were able to fully return to work or return with improved performance. The therapeutic approach was multimodal and personalized, and based in an extensive mix of behavioral and dietary changes, which included taking dietary supplements, control of cardiovascular health, stress management, between other interventions. The researcher concluded for the need to develop an RCT to verify these findings (Bredesen, 2014). Dietary changes had also been pointed out by Alzheimer's Research UK (2017) as one way to support healthy brain aging and reduce dementia risk.

Non-Pharmacological Treatment for Patients with DOC

Currently, three non-pharmacological treatments have shown positive effects in DOC populations and especially in the MCS, these are deep brain stimulation (DBS), sensory stimulation, and music (Gosseries et al., 2011b). Music therapy will be reviewed in its chapter (Schnakers, Magee, & Harris, 2016; Di & Schnakers, 2018). DBS consists of implanting electrodes in the brain, usually in the thalamus, to reactivate the widespread connectivity of neurons. A recent study by Lemeres et al. (2018) analyzed the effects of DBS in 5 patients with DOC, and they found that two patients showed improvement in auditory, visual and oromotor/verbal subscores, and visual subscores respectively within the CRS-R. Other study cases have been reported, but the technique although promising still needs further validation.

Sensory Stimulation (SS) consists in providing to the patient with DOC with frequent sensory input to the five senses, ideally with autobiographical and emotional content, and with the goals of enhancing synaptic reinnervation, accelerate recovery, prevent sensory deprivation, and further connect brain and body (Abbate, Trimarchi, Basile, Mazzuchi, & Devalle, 2014). The lack of human contact that DOC patients experience daily, between other sensory deprivation, it is believed that does not cooperate with their rehabilitation. However, according to Tamplin and Baker (2006), sensory stimulation is often unpleasant for the patient and does not help to motivate them to interact back with their environment. SS rationale is based on the concepts of covert responses, preserved islands of higher-order cognitive functioning, and integration favoring awareness evidenced in DOC populations (Abbate et al., 2014). The beneficial effects of this technique are still debated and are not yet based on much evidence (Di & Schnakers, 2018).

However, auditory stimulation combined with affective and tactile stimulation within a protocolized visit of families showed to be beneficial for DOC patients. In an RCT study with 50 subjects, the researchers found improvements in GCS scores in the intervention group throughout the 6 days of intervention, but not on the first day. Consequently, researchers suggested the need for regularity of visits and the possibility for nurses to adopt the protocolized visit approach used in the study (Abbasi, Mohammady, Sheaykh, & Rezayi, 2009).

Simulated Presence Therapy for Patients with Dementia

Simulated presence therapy (SPT) is the main non-musical auditory treatment for patients with dementia. The technique was first described by Woods (1995) and consists of presenting tapes to patients with recorded voices of their own family or surrogates to the patient. The approach was later extended to the use of videotapes on the preferred topics of the patient. A recent study case by Lim and Ong (2018) found that short videos recorded by the clinical psychologist and the occupational therapist, on topics preferred by the patient reduced behavioral symptoms and increased attention span in a patient with moderate dementia.

A bigger RCT study was recently published by Waszynski, Milner, Staff, and Molony (2018), including 111 hospitalized patients showing agitation or delirium, and most of them with pre-existing dementia. The study compared videos of the family sending a personalized message, videos of nature, and no videos, and found that both videos decreased agitation during and after the intervention, but family videos had stronger effect compared to nature video.

A Cochrane Review from Abraha et al. (2017) examined the effects of simulated presence therapy with people with dementia. Three trials with 144 participants with dementia, 2 trials were randomized and 1 quasi-randomized. The quality of evidence was considered low. Two studies showed no differences compared to personalized music. No effect was evidenced in distress or agitation of patients. All the authors provided conclusions of the benefits of SPT on behavioral outcomes, but overall, a great risk of bias was found in the three studies. A small adverse effect was reported in one study increasing agitation during treatment, by throwing the headphones away (Garland, Beer, Eppingstall, & O'Connor, 2007).

Auditory Non-Musical Treatments with Patients with DOC

Di et al. (2007) found that patients with VS and MCS showed differential brain activation when listening to their name said by a relative. In a study of 11 subjects (7 VS and 4 MCS) that underwent fMRI while a relative said their names, 2 VS subjects did not show significant activation, 3 VS subjects showed activation of primary auditory cortex, and 2 VS subjects with all the 4 MCS showed consistent activation of primary auditory cortex and higher-order associative temporal areas. Consequently, the two VS subjects were behaviorally evaluated and later categorized as MCS.

There is evidence that radio and significant auditory messages can increase physiological and behavioral responses with DOC patients. Ribeiros et al. (2014) conducted an RCT and analyzed blood pressure, respiration rate, heart rate, oxygen saturation, and facial expression of 26 patients with VS. The patients were grouped under 4 different music stimuli: radio, classical relaxing music, relaxing music with nature sounds, or no stimuli. They found that all sound stimuli affected the dependent variables. Radio produced a slight increase in all measures, except for facial expression that was not measured. Classical relaxing music produced a significant decrease in respiration rate and an increase in oxygen saturation and facial expression. While relaxing music with sounds of nature produced a significant increase in blood pressure, heart rate, respiration rate, and an increase in oxygen saturation.

Voices of relatives have shown increased responses in patients with DOC. Puggina (2011) performed an RCT study with 30 hospitalized patients with DOC undergoing four auditory conditions: relative's voice, classical music, preferable music, and sound of nature, and found that family voices elicited the higher stimulation measured both on physiological responses such as oxygen saturation, and breathing frequency. The content of the recorded message was affectionate, meaningful to the patient, and included their names at least three times. Puggina and Da Silva (2015) extended these findings studying 76 comatose patients, that underwent 3 different conditions: preferred music selected by their relatives, message recorded by their relatives, or control, and found significant changes in the patients' facial expression measured with electroneuromyography under both message and music stimulus, but music produced slightly higher responses.

SPT has also shown evidence with DOC populations. An RCT study with 15 subjects found that an intervention group that listened to messages recorded by relatives, on a dosage of 10 minutes, 4 times per day, with at least 2 hours in between, and for 6 weeks, showed improvements in the CNC score, and activation in language regions, and overall brain activity measured with fMRI (Pape et al., 2015).

In conclusion, there are positive effects of listening to the patient´s name, voices of relatives, regular visits of the family providing affective and auditory stimulation, and SPT in DOC populations.

Music Listening as a Treatment for Patients with Dementia

Listening to recorded music has recently appeared as a trending way to increase response in patients with severe dementia. A recent popular documentary by McDougald, Scully, and Rossato-Bennett (2014) presented an impressive outcome of a lethargic patient with severe dementia, becoming increasingly aroused when the interviewer provided his favorite music through headphones. The patient soon moved to the music, sang, opened his eyes wide, and showed an overall high level of alertness, and then, with appropriate questions the person regained his ability to verbally respond appropriately and with high energy.

Early study cases have shown various levels of physical responses to music presentation in patients with SSD (Norberg et al., 1986; Gaebler & Hemsley, 1991; Clair, 1996). In this chapter, the most updated evidence regarding music listening as a treatment for persons with dementia and especially the SSD will be presented.

A recent study found that listening to familiar music for 3 weeks, one hour daily, improved cognitive function and brain connectivity in subjects with early AD or MCI, being the effect higher for non-musicians (n=5) than musicians (n=4). The subjects underwent fMRI pre and post-intervention, at rest, and under the task of listening to familiar or to novel music. The researchers identified a Music Network consisting of the left cerebellum, bilateral temporal lobes, left inferior frontal gyrus, right basal ganglia, and bilateral superior marginal gyrus. Familiar music, though, activated the brain more bilaterally and extensively in emotional processing and frontal areas, including the bilateral cerebellum, inferior frontal gyrus, and putamen. The researchers suggested that this activation could be a compensatory mechanism and affect impaired executive function and emotions in patients with AD (Leggieri et al., 2018).

The fact that familiar music has shown to be more effective in triggering both memory and emotions has been consistently found in prior studies. Just to mention a few, a study case by Vanstone, Cuddy, Duffin, and Alexander (2009) showed the ability of patients with moderate to severe stages of dementia to retain lyrics and tunes of well-known songs. A repeated measures study by El Haj, Postal, and Allain (2012) with 12 patients with early dementia showed that more autobiographic memories and more emotional words were recalled by chosen music, compared to Vivaldi's Four Seasons, and silence. These findings were extended recently by Cuddy, Sikka, Silveira, Bai, Banstone, and Walla (2017) comparing the effects of Music-Evoked Autobiographical Memories (MEAMs) in younger adults, older adults, and older adults with mild to moderate AD. In general, the characteristics of MEAMs reflected the effects of age rather than disease. For AD, MEAMs may reveal a sense of self-identity that has been preserved despite neural degeneration and suggest musical memory to be better preserved than other types of memory.

To provide a rationale for the preservation of musical memory in AD, researchers studied the brain of both healthy and AD subjects undergoing fMRI, while retrieving long known and recently known songs. The researchers found significant results in the long-known task and suggested a network for musical memory that included the anterior cingulate and the ventral pre-supplementary motor area, which was embedded in a more widespread network, including anterior temporal, frontal polar and insular cortices. Interestingly, researchers found that key areas of the brain within this network showed less atrophy and hypometabolism compared to the rest of the brain in subjects with AD (Jacobsen, Stelzer, Fritz, Chételat, La Joie, & Turner, 2015).

An interesting and different approach was published by Guétin et al. (2009), who performed an RCT to study the effects of recorded music in anxiety and depression in a group of 59 older adults with early to moderate dementia. Both groups (music and control) received treatment once a week for four months. The music group listened to a 20-minute playlist of preferred recorded songs, organized using the "U-sequence method". This method consists of progressively reducing the musical rhythm, instrumentation, frequency and volume of the music (descending 'U' phase), followed by a phase of maximum relaxation (bottom 'U' segment), ending with a re-enlivening phase (ascending 'U' segment). The researchers found significant improvements in anxiety and depression in the music group and observed that improvements began in week 4 and continued through the rest of the sessions, up to 8 weeks after sessions were over. Unfortunately, this study claimed to be doing music therapy, and there was no evidence of a music therapist involved in the research appearing to be incurring in misconceptions about the discipline.

A recent review by Garrido et al. (2017) analyzed 28 studies using pre-recorded music with people with dementia. The researchers found positive effects reducing behavioral and affective symptoms like agitation, depression, and anxiety, even when a therapist was not present. In this regard, the authors mentioned that active music therapy may have greater benefits, but the positive outcomes from music listening led by trained caregivers were still noteworthy. Only one study compared the use of headphones and speakers, finding similar effects. They recommended the need to further define protocols that could consider both music preferences and desired symptom management. Nevertheless, individualized playlists with preferred music showed stronger effects, compared to researcher-selected music.

However, it appears that musical features like tempo and mode could be more relevant than music preference for a range of types of dementia. Regardless of the presence of voice, tempo and mode were recently found to have a significant effect on arousal and mood over-familiarity in subjects with multiple types of dementia from mild to severe. In a recent experimental study, personalized playlists were created to evaluate the effects of tempo, mode, and valence of lyrics and its presence, measured by galvanic skin response, facial action units, and reported measures of enjoyment. Slow tempos were more pleasantly reported compared with fast tempos, and both increased arousal levels. Major and minor music were associated with expected cultural responses for happiness and sadness. Surprisingly, voice and lyrics did not affect arousal levels or reported levels of enjoyment, which is usually opposed to the response of subjects without dementia (Garrido, Stevens, Chang, Dunne, & Perz, 2018).

A recent fMRI study published by King et al. (2019) found evidence of improved functional brain connectivity in patients with mild AD. The researchers analyzed brain images from 17 subjects, after listening to preferred music for 3 weeks and provided with an iPod. Brain images of subjects listening to their preferred music and then in reverse were compared using previously published parcellation of cortex and cerebellum. The researchers found consistent activation of the supplementary motor area and anterior insula during music listening task, and not during reverse music. These areas have been associated with memory for familiar music that is typically spared in early AD. They also found widespread increases in functional connectivity in corticocortical and corticocerebellar networks, suggesting a transient effect on brain function. In conclusion, their findings support a mechanism whereby attentional network activation in the brain's salience network may lead to improvements in brain network synchronization.

Music Listening as a Treatment for Patients with DOC

Sun and Chen (2015) performed an RCT (n= 40) to study the effects of music listening in DOC and found significant effects in the intervention group, measured by both $\delta+\theta/\alpha+\beta$ EEG value, and the Glasgow Coma Scale. The music stimuli consisted of songs of lively and relieved rhythm from different music styles to prevent habituation. The music dosage was from 15 to 30 minutes of favorite and familiar music, three times a day, for 4 weeks. The researchers found significant differences between the control group and the music group after treatment, measured on both GCS scores and $\delta+\theta/\alpha+\beta$ EEG values. Interestingly, these differences remained significant after a one-month follow-up, suggesting positive effects of preferred music listening on overall arousal of comatose patients.

In the same year Kotchoubey, Pavlov, and Kleber, (2015) reviewed the effects of music listening and music therapy treatments, presenting a rationale of biological, psychological. and neurophysiological foundations for the use of music with this population. The evidence reviewed points to the auditory sense being usually less impaired in DOC populations compared to the sight (see 4.2 Auditory functioning of persons with DOC). From there, music may interact with brain networks in charge of perception, speech, cognition, emotions, motor function, and connect to the self-consciousness of the person. Additionally, music-induced emotions and rhythmic stimulation can rehabilitate by affecting the dopaminergic reward-system, reducing stress, and increasing motor response.

Another study in the same year by Castro, Tillman, Luauté, Dailler, André-Obadia, and Perrin (2015) found that cognition can be boosted in DOC patients. Evoked related potentials (ERP) N2 and P3 using EEG were measured when patients listened to the patient's name and other common first names, after listening to one minute of either their favorite music or a continuous sound, which acted as a control. Researchers found an increased response to their names in the music condition, compared to control, and that a positive response to music was associated with a positive outcome regarding prognosis. These increased responses explained by overall cortical stimulation and autobiographical priming.

Recently, Grimm and Kreutz (2018) reviewed the effects of music as a treatment for patients with DOC. Regarding music listening, they found that familiarity of music was associated with positive behavioral and arousal effects, but also other contextual factors during music delivery were found to be important, such as the presence of a person during music stimulation.

Music Listening as a Treatment for Patients with Stroke

Särkämö et al. (2008) thoroughly studied the effects of music listening on acute stroke patients and found that music listening can enhance cognitive recovery. They performed a single-blinded RCT with 54 early post-stroke patients, everyone with a medial cerebral artery stroke, and undergoing between 1 to 2 hours of either self-selected music listening, audiobooks listening, or no listening stimulation for a duration of 2 months. Through neuropsychological test battery and mood questionnaires, found that in the within-subject level the music group showed significant increases of focused attention, verbal memory, and enhancement of mood, results that were maintained after 3- and 6-months follow-up.

On a posterior analysis of the same subjects (Särkämö et al., 2010), the researchers expanded these findings using magnetoencephalographic measures of auditory ERPs using the mismatch negativity [MMN] component. Using this method, the researchers found that both interventions showed significant responses of the MMN component, suggesting that both could be used to improve auditory sensory memory and enhance cognitive recovery. Although coupled with the previous study, the effects of the book listening intervention seemed limited to low-level temporal auditory processing, while the responses of the music group appeared stronger in both studies.

Later, Forsblom, Särkämö, Laitinen, and Tervaniemi (2010) studied the self-reports of the same group of patients, and from a quantitative and qualitative perspective found that the music-listening group reported improvements on relaxation, motor activity, and mood. Interestingly, patients were able to do other motor tasks while they listened to music, different from the audiobooks group that reported to be less able to concentrate on other tasks. While both groups reported being a refreshing stimulation and evoking memories, the audiobook group reported more to be aware of the stroke and feeling depressed than the music group.

Lastly, the group analyzed the fMRI results of the same sample (Särkämö et al., 2014) and found significant increases of Grey Matter Volume [GMV] for all the three conditions after the 2-months treatment, but the music group produced larger increases of GMV, specifically in a network of frontolimbic areas, primarily in the healthy contralesional side, but also perilesionally. The frontolimbic areas correlate with previous behavioral findings, frontal areas for cognitive increases of attention and language, and limbic areas for mood enhancement. They also found less activation of GMV on the right hemispheric damage group, possibly due to larger damage on these patients compared to the group with damage on the left side, or because an inability of the music to engage these patients when music processing has shown to have a right hemispheric dominance (Zatorre et al., 2002; Tervaniemi & Hugdahl, 2003, as cited in Särkämö 2014). The text ends claiming to be "the first evidence in humans that not only active therapist-led rehabilitation but also environmental enrichment has the potential to shape the structure of the recovering brain" (p. 13).

Music Therapy Treatments and Techniques with Patients with Dementia

Early study cases have shown various levels of response and participation of patients with SSD to different music therapy (MT) interventions, such as rhythmic group interventions (Clair & Bernstein, 1990; Clair, Bernstein, & Johnson, 1995), and listening and singing (Clair, 1996), with positive but no conclusive effects of MT. The wide range of responses was addressed to individual characteristics and duration of data collection since patients could become more responsive by participating in MT programs for increased periods (Clair, 1996). Musicians, for example, could show an increased response in the SSD. There is a reported case of an 82 years-old male person with AD, with high training in piano, that showed preserved ability to play, but not the recalling of the names of compositions; highlighting the differences of ability between procedural and declarative memory (Crystal, Grober, & Masur, 1989).

The first meta-analysis of MT on dementia was published by Koger and Brotons (2000). They examined 21 studies and found positive and significant results in maintaining and treating symptoms of dementia but did not identify the most effective techniques. They also found no RCTs and an overall weak methodological evidence. The following review by Ridder (2005) included 92 studies of music and dementia and MT books from 1980 to 2004. Seventeen different therapeutic initiatives were identified, serving a group of seven general purposes, and describing four main functions of music: evaluative, regulative, stimulative, and communicative. The researcher pointed to the positive results in social interaction, cognition, and the need to combine the four approaches to enhance access to the person with dementia.

Consistent with these findings, music therapy has shown effectiveness in decreasing behavioral and psychological symptoms of dementia (BPSD) in patients with moderate and severe stages. Raglio et al. (2008) studied 59 patients with moderate to late stage of dementia undergoing either MT or educational/leisure activities. The experimental group received 3 cycles of 10 active MT sessions (30 min/session) with a nonverbal approach, where both rhythmical and melodic instruments promoted communication through nonverbal behaviors. Whereas the control group underwent educational (ie, personal care, lunch, bath, cognitive stimulation) and entertainment activities. Neuropsychiatry Inventory test significantly decreased in the experimental group by week 8th and maintained until week 20th, and the effects were more specific for delusions, agitation, anxiety, apathy, irritability, aberrant motor activity, and nighttime behavior disturbances. Additionally, the empathetic relationship and the patients' active participation in the MT approach also improved in the experimental group.

Despite extensive publication showing positive effects of MT improving behavioral, emotional, social, and cognitive function in patients with dementia, the evidence has been found to have considerable limitations. A *Cochrane Review* by Vink, Bruinsma, and Scholten (2003, 2011) found 10 RCTs using music therapy to treat patients with dementia. However, the studies reviewed lacked good methodological quality, had a small sample size, and the variability of behavioral, psychological, and functional scales used in the studies was spared, making it difficult to pool the results into unified outcomes.

Therefore, the narrative synthesis systematic review published by McDermott, Crellin, Ridder, and Orrel (2012) has a unique value to better understand the impact of MT in the treatment of patients with moderate to severe dementia. The researchers included 18 studies, accounting for a total of 589 subjects, that examined the effects of MT improving behavioral and psychological symptoms, hormonal and physiological changes, and social and relational aspects. Singing was found to be one of the most important mediums for change. The researchers concluded to find consistent improvement in mood and reduction of behavioral disturbances with MT interventions, but a lack of high-quality longitudinal studies to show long-term benefits.

The active approach in MT has found positive results in a group of several studies from recent years. Särkämö et al. (2013) compared the effects of regular musical activities in patients with mild/moderate dementia (n=89). The researchers compared a singing coaching group that also covered vocal and rhythmic movements, with a music listening coaching group that also did reminiscence and discussion, and both compared to a control group. They found that both singing and music listening improved mood, orientation, and remote episodic memory, and to a lesser extent, also attention and executive function and general cognition. Singing also enhanced short-term and working memory and caregiver well-being, whereas music listening had a positive effect on increasing quality of life.

It appears that an active and small-group approach in MT could be more beneficial than simply listening to music to decrease BPSD in patients with SSD. A more in-depth evaluation of MT strategies to decrease BPSD in patients with SSD was published by Sakamoto, Ando, and Tsutou (2013). The researchers performed an RCT with 39 subjects separated into three groups of active music, passive music, and no stimulation (control). Each intervention lasted 30 minutes, once a week, for 10 weeks. Both intervention groups using music were associated with positive memories and were found to be significantly effective in decreasing stress, while increasing relaxation and positive mood immediately after the intervention compared to the control group. Surprisingly, the active group showed increased parasympathethic activity than the passive group, probably due to reduction of stress and positive mood changes. The study also found long-term benefits in both groups within the items of affective disturbance, and anxieties and phobias. However, the differences found were that music listening was found to reduce stress, induce laughter, and evoke positive memories. while the active group showed improvements in 5 areas: affective disturbance, anxieties and phobias, paranoid and delusional ideation, aggressiveness, and activity disturbance. Additionally, the active group showed reduced caregiver burden. The reduction of BPSD was significant in the active group compared with the other two groups. These changes were observed two weeks after the intervention, but disappeared by the third week, pointing to the need of continuity of the intervention. This positive effect of active social music therapy was also found in the RCT published by Ray and Mittelman (2015), decreasing agitation and depression in patients with moderate and moderately severe dementia.

A recent *Cochrane Review* by Van Der Steen et al. (2018) analyzed the evidence of music-based therapeutic interventions for people with dementia, and its effects on emotional well-being, quality of life, mood disturbance or negative affect, behavioral problems, social behavior, and cognition at the end of therapy, and four or more weeks after the end of treatment. They included 22 RCTs, accounting for a total of 1097 participants, using individual and group therapeutic interventions, active and receptive approaches, and delivered by music therapists and not. Additionally, post hoc sensitivity analysis differentiated the studies delivered by music therapists. They concluded finding moderate-quality evidence of effects reducing depressive symptoms and overall behavioral problems after five sessions, and smaller effects were found on decreasing agitation or aggression. The authors indicated that music-based interventions may also improve emotional well-being and quality of life, but no evidence was found for cognition. The study recommended that future studies should improve the risk of bias and examine the duration of effects concerning the duration of treatment and number of sessions.

The effects of MT in cognition in patients with dementia are still scarce and conflictive, and up to date, it could have better effects on global cognition, autobiographical memory, and more effective in the mild stage of dementia. A systematic review and meta-analysis of cognitive effects of music therapy in patients with dementia published by Fusar-Poli, Bieleninik, Brondino, Chen, and Gold (2017) found no significant improvements. The study reviewed 6 eligible RCTs studies accounting for a total of 330 subjects examined. Subgroup analysis found evidence and significance of a beneficial effect of active MT on global cognition. Another systematic review by Moreira, Justi, and Moreira (2018) that studied the effects of MT on memory in patients with AD. They reviewed only four eligible RCTs including a total of 258 subjects studied. The researchers presented the heterogeneity of results and types of interventions and found positive but conflictive evidence regarding working memory, long-term semantic, and more strong outcomes in autobiographical memory. The researchers concluded that MT may be effective, but it remains unclear if MT could have or not effects on short and long-term memory due to the small number of eligible RCTs. The researchers recommended the need to report dementia type, duration, the severity of symptoms, and level of education in future studies.

The key to the treatment for patients with AD seems to be in the development of individualized music regimens. According to a recent review that analyzed 6 eligible studies from the past 10 years, analyzing either music listening interventions or MT showed that while receptive interventions could increase relaxation in the long-term, active interventions improved social interaction and provided acute benefits. They showed evidence as well for the cognitive and behavioral effects of both interventions (Leggieri et al., 2019). The lack of effects in cognitive domains in the reviews by Van Der Steen et al., (2018) could be because only 6 out of 24 RCT used an individualized music approach. The same might have happened with the review by Fusar-Poli et al. (2017) that only found global cognition effects, but only 2 out of 6 presented an individualized component of treatment.

The positive social, behavioral, cognitive, emotional, and physical outcomes in patients with dementia could be due to the power of music to connect the self of the patient. A current theoretical framework by Baird and Thompson (2018) explains how music enhances the self in patients with dementia. The theory was based on Neisser's framework of the self, which divides it the self in five aspects, ecological, interpersonal, extended, private, and conceptual. The auditory and sensory inputs of music connect the ecological self through physical, synchronous, engaging, and emotional features of music. Group musical activities connects the interpersonal self through persuasive and engaging social features of music. Various forms of musical engagement like listening and playing connects with the extended self, to the past through autobiographic memories, and to the future could be connected when a musician with dementia practices to maintain and improve their skill. Music can elicit memories, thoughts, and emotions connecting with the private self. Lastly, music connects the conceptual self by engaging past or new identities, traits, roles, and preferences. Researchers conclude that the framework could be useful for the diagnosis and treatment of impairments of self in people with dementia, that by stimulating the various parts of the self, the result is an enhanced sense of self. Finally, the researchers suggest that specially personally preferred music engage the brain structures related to self-referential processing, like the cortical midline structures of the Default Mode Network.

According to the recent review by Groussard, Chan, Coppalle, and Platel (2019) on preserved memory function in subjects with AD, therapeutic interventions with patients with SSD should rely upon semantic memory and a sense of familiarity with subjects as a way to successfully engage unimpaired memory functions. Whereas in mild and moderate stages the well preserved musical semantic memory and the possibilities to use mnemonic devices to learn new information, together with the relations between positive emotions and improved memory function should be addressed in therapeutic interventions.

To finish this section of MT techniques with patients with SSD, two approaches will be reviewed, NMT, and MT combined with SS. The first NMT technique appropriate for patients with SSD is Musical Sensory Orientation Training (MSOT), and it is used to address patients that have affected attention, arousal, vigilance, and sensory responses. The technique uses live or recorded music to stimulate arousal, recovery of wake states, meaningful responses, orientation and uses active engagement of simple musical exercises in more advanced recovery stages (Thaut, 2005). According to Myskja (2014) the technique could be appropriate for patients with DOC, severe developmental disabilities, and dementia. The researcher presented five different protocols within the technique: sensory stimulation, arousal and orientation, vigilance and attention maintenance, care singing for washing and other procedures in dementia and DOC, and individualized music (pre-recorded and live) to regulate sensory stimulation, arousal, and attention.

In a recent pilot study by Holden et al. (2019), an NMT home-based program was evaluated in the management of BPSD in patients with mild to moderate-to-severe stage of dementia. A combination of MSOT, and two other NMT techniques Musical Attention Control Training (MACT) and Associative Mood and Memory Training (AMMT) were used within the program. MACT uses musical elements to cue different musical responses to practice sustained, selective, divided, and alternating attention functions, while AMMT utilizes music to alter mood and enhance mood-dependent memories that can enhance recall of positive memories. The dosage of treatment was delivered during one-hour weekly, through 6 weeks of duration, evaluated then and at 12 weeks after treatment. Four patients with a more severe stage could not finish the treatment due to hospitalization or moving to a nursing home, which was interpreted that a severe stage could be too late in the progression of the disease to intervene using the pilot program. For those who completed therapy, neuropsychiatric symptom scores improved at 6 weeks, an effect that was sustained at 12 weeks. The researchers concluded that the approach was not suited for severe stage patients and more appropriate in the milder stages of the disease.

The other approach is called Music Therapy Multi-Sensory Stimulation (MT-MSS), a recently combined therapy proposed in a Master Thesis by Lim (2016). She presented 3 successful study cases, using this technique to both assess and manage symptoms in patients with SSD. The protocol consisted of using familiar songs mixed with the presentation of sensory objects interconnected through the lyrics. Positive results were found in alert behaviors, music participation, verbal or nonverbal communication, positive mood/behaviors, meaningful interaction, memory, and quality of life, and decrease of negative mood behaviors and agitated behaviors. The researcher presented also the MT-MSS Assessment Tool to track the remaining responses of the patients through the created technique, the tool was based on the INTERACT, a questionnaire developed in MSSE studies. This approach could be an enhanced solution to a published RCT study that found higher effects in an MSSE group compared to a music listening group (Sánchez et al., 2016). Even though MSSE was not compared to MT, and rather to free field listening of preferred songs in a room, it still points to a limitation of passive reception of music, acknowledged by Lim (2016) in her discussion, and therefore pointing to the relevance of including other sensory input in the treatment and assessment of patients with SSD.

Music Therapy Treatments and Techniques with Patients with DOC

In general, MT techniques used in the literature with this population are divided into two groups: (1) the humanist/music-centered model, which believes in the existence of a soul and body separated in the concept of consciousness (Aldridge, Gustorff, & Hannlich, 1990; Gustorff, 1995; Gustorff, 2002); (2) the behavioral/pragmatic model where brain function defines consciousness (Baker & Tamplin, 2006; Boyle, 1994; Boyle & Greer, 1984; Magee, 2005; Magee et al. 2013; O'Kelly & Magee 2013a and 2013b).

The first published study with this population, and the first one to find positive results on this subject was performed by Boyle and Greer (1983). They presented contingent preferred music to three VS patients when a certain behavior occurred. From a behaviorist approach, they found an increase in all the motor target behaviors, suggesting implications of MT on the assessment of awareness of these patients. Seven years later, Aldridge, Gustorff, and Hannich (1990) presented 5 study cases with patients in a coma where a music therapist treated them from a humanistic approach rooted on the Nordoff-Robbins method, during short sessions of 8 to 12 minutes, and utilizing wordless improvised singing entrained to their breathing rate. They found different responses: changes in breathing, fine motor movements, grabbing movements of the hand, turning the head, eyes opening to the regaining of consciousness, and faster brainwaves measured by EEG, all of them suggesting increased arousal. Two philosophical ideas behind their treatment were that music could help these patients to entrain the many disorganized rhythms they experience due to brain damage and that proper breathing is fundamental for the recovery of these patients (Aldridge, 2003). Afterward, Kennelly and Edwards (1997) published two study cases in the Pediatric Intensive Care Unit with children in a coma. The two children received five and thirteen MT sessions each one. During the presentation of known songs, they elicited a range of reactions such as crying, movement of the limbs, attempts to speak, eye-opening, staring to the guitar, vocalizations, and changes in breathing.

Three years later, Tamplin (2000) summarized the three music therapy techniques used within the seven different studies published to that date, including the three articles mentioned before and included the presentation of live familiar songs (with adaptations like word substitution and song parody), listening to recorded music, and improvised singing/playing. While she supported the active engagement that the behaviorist approach was pursuing, she suggested an integration of both approaches, through active music improvisation with the patients' physiological rhythms. She presented 4 study cases of comatose patients treated with music improvisation entrained to the heart and breath rate, similar to the Aldridge et al. (1990) study. She found similar responses to those reported, supporting the evidence of increased awareness and arousal during music therapy treatment, but also reported that one of the four subjects did not respond to the treatment at all, and was later discharged. Formisano et al. (2001) using also improvisation techniques found a significant decrease of psychomotor agitation and inertia on most of the treated patients.

The development of a relationship seems to be also important with comatose patients. According to Ghiozzi (2005), the first step to achieving this is to interview the relatives. Specifically, this interview looks to find important information about the patient's different phases from childhood to the present, personality character, academic studies, musical background, interests (literature, sports, hobbies, etc.), favorite flavors-scents (as well as flavors-scents from the family environments and work), spiritual background, relationship with family members, and physical reactions seen by their family members during hospitalization. After this interview observation sessions are carried out assessing the following elements: calibrationmodeling-mirroring of the voice to the breathing pattern of the client, rotation of three perception positions, micro-movements (including breathing and physiology in general), reactions to environment stimuli, prompt-test of recorded songs, and contact between the therapist and client's deep self. He also mentioned that the therapy should be directed in such a way that it helped the patients to regain a sense of rhythm, a reason to intervene always on the same days and hours.

The first published review of MT techniques with comatose patients was written by Baker and Tamplin (2006). They stated that the first thing a clinician might consider when working with a patient in coma are the different musical and acoustic possibilities of the music stimuli, that simple and predictable musical stimuli can be better processed by them and prevent over-stimulation. They encouraged to include the voice in the music in order to add a human component to the relation, the patient's preferred music, and improvisation in isolation or in combination with preferred music and entrained to the breathing patterns of the patent. They also mentioned that MT might be helpful for the family members, offering them means of communication with their loved ones, and a diversion from daily routine.

The creative approach used by Lichtensztjen, Macchi, and Lischinsky (2014), which has its roots on the Nordoff-Robbins model of music therapy, involves that "the therapist’s attention should be directed to the potential changes in breathing, blinking, and subtle movement of the face or limbs as observations denoting behavioral responses" (p.49). Herkenrath (as cited in Lichtensztjen, Macchi, and Lischinsky, 2014) described how music can help these clients to direct their consciousness to different parts of the body, through pairing music sounds with different subtle movements of the patient's body in itself or connected to instruments, therefore including these movements into the musical improvisation. Therefore, live music presents advantages over recorded music when performed by trained music therapists, as they can modify the performance to match the limited processing capacity of the patient, to respond in real time to changes in patient´s arousal levels, and to "incorporate salient material such as the patients' names in improvised material" (Magee & O'Kelly, 2014, p. 258). This is congruent with the findings of O'Kelly et al. (2013) of increased awareness for live music, found in both healthy and DOC patients measured by EEG and respiration rate.

A few MT studies have tried to evaluate the level of responsiveness to music and MT techniques with this population. O'Kelly et al., (2013) compared 20 healthy participants to 21 DOC patients (12 VS and 9 MCS) while receiving different auditory stimuli: live preferred music, improvised music entrained to respiration, disliked music, and white noise. Brain activity was measured with EEG, while heart rate, heart rate variability, respiration, and behavioral responses were collected. The researchers found significant increases in respiration rate and global increases in brain activity mostly on the right frontal and temporal regions during live music across healthy subjects. While the patients' cohort responded heterogeneously, significant increases of brain activity were found in the frontal midline theta in ten patients, and frontal alpha in seven patients during the preferred music condition. Behavioral data found a significant increase in the blinking rate on the patients' group. Another interesting finding is that all tempos from the musical stimuli were compared to concurrent respiration rate and found no entrainment of physiological responses due to the rhythmic element of the music. While heart rate and heart rate variability presented different responses on different subjects, the effects were significant at the within-subjects level. The literature presented in this peer-reviewed article suggested that most of the effects elicited by the MT techniques proceed from healthy-awareness processes, indicating arousal and selective attention. Finally, "the EEG data coupled with the Respiration

Rate increases observed for Live Music provides evidence from a normative perspective for the utility of using this music therapy procedure to support arousal and 'top-down' cortical activity with DOC" (O'Kelly, 2014, p.52).

Individual Dialogic Music Therapy (IDMT) is a technique where the MT improvises live music and modifies the music according to the different physiological and minimal motor responses of the patient with DOC, such as blinking, breathing, and subtle movements of face and limbs to increase the patient´s non-verbal effective communication. Binzer et al. (2016) studied this approach and stated that the technique is analogous to other prior music therapy techniques with this population (Tamplin, 2000), but with a lack of evidence and related assessment tools. The researchers studied seven adult patients being either on VS or MCS and compared IDMT with typical environmental sounds found on their daily living in the hospital. They found higher scores on MT treatment measured by the "Music Therapy in a Vegetative or the Minimally Conscious States", which measures visual, motor, auditory, oral, communication, and vigilance. Immediate responses were found during the IDMT treatment on all domains, although only reaching significance on the visual and auditory domains.

Recently, Grimm and Kreutz (2018) published a systematic review of 22 quantitative music studies published between the years 1983 and 2016, including three RCTs, and accounting for a total of 329 persons with DOC. The researchers divided the studies according to the type of intervention: active MT, preferred recorded music, combined preferred music (with live and relaxation music), music combined with other sensory interventions (musicokinetic therapy with massage, verbal messages), and recorded selected music. The dependent variables measured were behavior, physiological responses, general condition, and brain activity. They found different kinds of positive outcomes in all studies, but significantly strong effects on the presentation of biographic music and interactive music settings, "suggesting the combination of the two as preferred forms of music interventions" (p.8). However, they stated clearly that it is not possible yet to define the best treatment because of the heterogeneity of the studies. They suggest that new studies have to account both for details on intrinsic (structural) and extrinsic (preference) factors of music, delivery (live vs. recorded), selection procedures, and diagnosis.

Risks of Harm of Music Interventions with Patients with SSD, DOC and in Intensive Care

Only one article was found that addressed uniquely the risk aspects of the use of music with dementia. For the most part, only anecdotes were found to be spread in a few different publications with patients with DOC, dementia, and intensive care. These publications could be categorized in either risk of harm for the patient due to negative associations (Bright & Signorelli, 1999), or due to negative physiological response (Tamplin, 2000; Trappe, 2012). Only one publication addressed directly concerns about the use of music listening programs (Swayne, 2014).

However, Assagioli (1965), a psychoanalyst, was one of the first ones to address the harmful effects of music in the human body and mind. He said that many factors could give the music a detrimental use, such as quality, amount, combination and succession of different types of music; the psychological constitution of the listener; and his or her current emotional state. He mentioned the documented cases of musicogenic epilepsy and prevented about the styles of music that could increase negative emotions such as sadness and confusion, and with increased risk of harm to people with a weak psychological constitution. He finished his paper mentioning the risks for music performers on the development of fatigue, anxiety, mood changes and prevented the negative effects of suggestive music paired with images in film production.

Risks of harm due to conflictive associations were mentioned by Tamplin (2000), warning about the risk of presenting music to the patients that could trigger traumatic memories unable to be resolved. This based on the case by Bright and Signorelli (as cited by Tamplin, 2000; as cited by Siqueira, 2013) where a DOC patient presented signs of distress while listening to a certain music style and this style was no longer played.

Risks of harm due to probable physiological responses were suggested by Trappe (2012), pointing that heavy metal and techno could be possibly dangerous and lead to stress and/or life-threatening arrhythmias in intensive care medicine, this due to autonomic increases of heart rate and blood pressure. This is consistent with recent findings by Garrido, Stevens, Chang, Dunne, and Perz (2018), where faster tempos had shown to increase response and decrease enjoyment in people in aged care settings.

Swayne (2014) criticized music listening programs for dementia patients of the type from the documentary *Alive Inside*, mentioning the risks for the patients of taking their reminiscing as real, and the possibility to increase the confusion of the patients due to false memories triggered by the musical experience. He highlighted the fact that most of the severe dementia patients are unable to consent, and where music could increase motor response against their will, increase reminiscence of negative distressing memories or increase confusion and anxiety if they are awakened by familiar sounds into an unfamiliar world. Additionally, in another study, the use of headphones was reported to increase agitation in a patient with SSD by throwing the headphones away (Garland, Beer, Eppingstall, & O'Connor, 2007).

In the Great Lakes regional music therapy conference in 2018, a panel discussion about the music listening programs in geriatric care settings. It was facilitated by the board-certified music therapists (BC-MTs) James Hiller, Jessica Josefczyk, and Annie Heiderscheit (2018).

They highlighted the ethical and risks of psychological harm provided by non-music therapists and delivered with a possible insufficient level of training in the awareness and mitigation of risks of harm during music listening interventions in people with dementia.

CHAPTER III: METHOD

Participants

This was a sample of convenience. The criteria for inclusion were to score either a level 2 or 3 in the Clinical Dementia Rating (CDR) scale, to score between 5 and 7 in the Global Deterioration Scale (GDS) and to have a legal person to consent for them. The criterion for exclusion was having a profound hearing impairment such as deafness, reported by a knowledgeable caregiver or clinical chart, and there was no age limit. Permission was provided and signed by the legal representatives of the participants. Five participants were selected by the activity's director and the administrator of two local nursing homes according to inclusion and exclusion criteria. Two participants at the end-stage dementia died before the data collection started. Another private participant was included by direct request of his spouse with the researcher. Participant 1 (P1) was an 82 years old, female, living in a nursing home, having a high-school level of education, no hearing impairment, severe level of dementia (CDR 3, GDS 7) of a mixed type, and a speech characterized as non-verbal but having few words to communicate. Participant 2 (P2) was a 97 years old, female, living in a nursing home, having a bachelor level of education, hearing loss on one side and total deafness on the other side, with a moderately severe level of dementia (CDR 3, GDS 6) of Alzheimer's type, speech characterized by bradylalia, jaw tremors, and dysarthria. Participant 3 (P3) was an 81 years old, male, veteran of the army, living in his private home, with hearing loss but having a corrective hearing device, he had an unclear diagnosis of either Alzheimer's or Frontotemporal type of dementia at a moderate level (CDR 2, GDS 5), his speech was characterized functional but presenting intermittent repetitive phrases and words. Lastly, participant 4 (P4) was 71 years old, female, with a bachelor level of education, living in a nursing home, with no hearing impairment, a diagnosis of vascular dementia due to right stroke, a moderate level of deterioration (CDR 3, GDS 6), and a speech characterized by emotional dysprosody. All this information is summarized in table 1.

Table 1

Participant's Demographics

P	G	A	E	H	HI	DT	SOD	SCh
P1	F	82	High school	NH	No	Mixed	Severe (CDR 3, GDS 7)	Non-verbal, few words
P2	F	97	Bachelor	NH	Yes	AD	Moderately severe (CDR 3, GDS 6)	Bradilalia Jaw tremors Dysarthria
P3	M	81	Veteran	PH	Yes	AD or FTD	Moderate (CDR 2, GDS 5)	Intermittently stereotypical
P4	F	71	Bachelor	NH	No	VaD due to right stroke	Moderately severe (CDR 3, GDS 6)	Emotional dysprosody

P= Participant; G= Gender; A= Age; E= Education; H= Housing; NH= Nursing home, PH= Private home HI= Hearing impairment; DT= Dementia type; AD= Alzheimer's disease; FTD= Frontotemporal dementia; VaD= Vascular dementia; SOD= Severity of dementia; CDR= Clinical dementia rating scale; GDS= Global deterioration scale; SCh= Speech characterization.

Setting

Long-term care nursing facilities and a private participant were determined by convenience of willingness to participate, taking care of people with severe dementia, and for being local. Three local long-term care nursing facilities were contacted by the researcher with the study proposal and a recruitment letter. The administrators and activities directors of two facilities answered back and agreed to participate. In the facilities the sessions were delivered in the private room of the participants and in a private conference room, where only the researcher and the patient were present. In the case of the private participant, the sessions were delivered in the dining room, where a hired caregiver was present with the researcher and the participant, and occasionally the wife of the participant was present too. With him, the room was silent for most of the data collection, but occasional distractions occurred when his wife was walking by or talking to the participant.

Design

This was a mixed methods case study with a repeated measures design.

Recruitment/Data Collection

` A recruitment letter was sent to the possible participants' legal representatives by either the researcher, the administrator, or the activities director of each facility. A total of six participants (five from nursing homes and one from a private residence) answered back and consent forms were emailed or given for them to sign. Two participant's legal representatives signed but the participants died before initiating the data collection. Once the consents were signed the data collection lasted four weeks. Consent form can be found in Appendix A.

Measures

Three conceptual variables were studied of awareness, dementia deterioration, and signs of enhanced sense of self. The corresponding operational variables for these concepts were the MATADOC scores, the GDS and CDR scores, the behavioral/thematic video analysis with appearance/absence of identified behaviors/themes, and the caregiver's reports. See Table 2.

The study aimed to identify the effects of three different auditory conditions on increasing awareness levels measured by the MATADOC or signs of enhanced sense of self. Therefore, three independent variables were studied during the comparison of treatment conditions: auditory simulated presence therapy, listening to recorded songs, and live music therapy. Whereas the dependent variables were the MATADOC scores, behaviors and themes from video analysis, and reports from caregivers.

Table 2

Conceptual and Operational Variables of the Study

Conceptual variables	**Operational variables**
Awareness	MATADOC scores and MATADOC qualitative findings
Dementia deterioration	GDS and CDR scores
Signs of enhanced sense of self	Behavioral/thematic analysis with appearance/absence of identified behaviors/themes. Caregiver's reports.

As a mixed methods study, the qualitative data included the narratives of the sessions, the baseline MATADOC descriptive reports, and the behavioral/thematic video analysis of the sessions. Whereas, the quantitative data included the CDR and GDS scores measured at baseline, and the baseline MATADOC scores and the changes after each treatment condition within the 14 assessed domains: visual, auditory, awareness of musical stimuli, verbal commands, arousal, behavioral response to music, musical response, vocalization, non-verbal communication, choice-making, motor skills, attention to task, intentional behavior, and emotional response.

The concept of awareness has been defined as the ability and the act of having an experience of any kind (Royal College of Physicians, 2013). Whereas, the enhanced sense of self is a theoretical construct elaborated by Baird and Thompson (2018) to frame the enhancement of human functions in patients with dementia when exposed to music stimulation. Studying only *awareness* was not appropriate for this study since participants with a moderate and moderately severe stage of dementia do not show signs of low awareness of the DOC type, as patients at the end-stage of dementia usually do. Therefore, a more appropriate concept of *sense of self* was used referring to the act of having experiences of any kind that directly related to one individual, encompassing affective, psychological, cognitive, extended, situated, and other relevant areas of that individual. A wide range of behaviors indicating improved functioning in these areas were considered and were identified in the analysis of videos and narratives.

Regarding the scales used in the study, the CDR is widely used in research to group participants by severity (Sheehan, 2012). The current version and scoring rules were first published by Morris (1993) and assess the level of impairment of patients with dementia in questionable, mild, moderate, and severe. According to a systematic review published by Olde Rikkert (2012) the CDR validity and reliability has been consistently studied and it appears to have a high inter-rater reliability with an intraclass correlation: > 80%, a medium concurrent validity with a correlation > 0.50, and a very strong discriminant validity. Overall, the CDR appears as the best-evidenced staging scale, it has been studied in international perspective, and it is available in 14 languages. Nevertheless, the researcher points to the need to refine current global rating scales.

The GDS is also widely used in research to group participants by severity (Sheehan, 2012). It was first validated by Reisberg, Ferris, de Leon, and Crook (1982) with a sample of 54 patients. They identified a significant correlation with 13 of the 19 cognitive items in the Inventory of Psychic and Somatic Complaints in the Elderly and with 25 of 25 other psychometric measures. Additionally, they found significant relationships between the GDS and changes observed in both computerized tomographic (CT) scans and in positron emission tomography (PET) scans. Nevertheless, it appeared that the validity of the GDS could be difficult to assess without appropriate longitudinal studies, and there might be some inconsistencies between stage descriptions and appearance at least of psychiatric symptoms (Eisdorfer et al., 1992). According to a systematic review by Olde Rikkert et al. (2011), the GDS has not been appropriately assessed for reliability.

The MATADOC was validated using five years of medical records from 42 patients, the researchers compared MATADOC with the SMART, a popular scale used with DOC patients, and found a high agreement between the two scales, but with different sensitivity. MATADOC showed higher scores on auditory and visual domains, while SMART showed higher scores on the motor domain. They concluded that both assessments used in combination provided unique information predictive of a patient's awareness (O'Kelly & Magee, 2013b). Afterward, the researchers measured the psychometric characteristics of the three subscales. First, Magee, Siegert, Daveson, Lenton-Smith, and Taylor (2014) measured psychometric characteristics of the principal subscale and found 100% agreement with the SMART scale, with a cohort of 21 subjects with DOC. The five items showed satisfactory internal reliability and a strong first principal component, confirming the MATADOC Principal Subscale as a robust uni-dimensional and homogenous subscale for assessing awareness in patients with DOC. Later, Magee, Siegert, Taylor, Daveson, & Lenton-Smith (2016) measured psychometric characteristics of the subscales two and three, finding mixed results. Four items showed 'adequate' Inter-Rater Reliability [IRR] and Test-Retest Reliability [TRR], two others reached just below the line for 'adequate', and other three items were poorly scored: 'choice-making' showed poor IRR, 'musical response' both poor IRR and TRR, and 'behavioral response' poor consistency with 'musical response' item. These differences were discussed in terms of scoring, assessor experience, and MATADOC training. The variability for 'choice-making' might be rooted in the inability of VS patients to communicate, and it is, therefore, an item pertinent to the MCS patients. Overall, the results for subscales two and three point to a work in progress, nevertheless they do not have diagnostic value and mostly provide important information for staff and the music therapy treatment.

The Music Therapy Patient Profile and Preference Questionnaire (MTPPPQ) is a questionnaire to identify relevant musical information for patients with DOC and it is included as an appendix in the MATADOC guidelines (Magee, Lenton-Smith, & Daveson, 2015).

Procedures

On the first two weeks the researcher contacted the legal representative for an interview to identify salient individual musical information of the participant and to record the messages for the auditory simulated presence therapy (ASPT) condition. Three interviews were conducted in person and messages were recorded in a sound booth, and one interview was conducted remotely through phone and messages were recorded with a smart phone and sent to the researcher by email. Afterward, the researcher organized a recorded playlist with the identified favorite/familiar music of the participant for the recorded song (RS) condition, learned these songs to play them during the live music therapy (LMT) condition, and edited a playlist with the recorded messages for the ASPT condition. The third week the MATADOC assessment was performed for the participants and scores were collected throughout 4 sessions and within 5 days, and each assessment session lasted between 30 to 45 minutes. In the fourth week, and on different days the three conditions: ASPT, RS, and LMT were delivered during no more than 30 minutes followed by a single MATADOC session performed immediately after each condition. The order of the conditions was set different for each participant to control for cumulative effects.

MATADOC Baseline

To assess the level of awareness of the participants, four individual sessions of 30 to 45 minutes were conducted within five days using the MATADOC protocol. This protocol consists in a first behavioral observation during three minutes and 30 seconds of rest; followed by an introduction of musical stimulus through a hello song; presentation of only visual stimuli over the four quadrants; presentation of only auditory stimuli to both sides using tone chimes, guitar, and voice; presentation of verbal commands related to a musical material; and a presentation of salient familiar musical stimuli (mostly live, but recorded music was also assessed); additional procedures such as reading music or playing musical instruments; a closing song improvised or familiar; and a final post behavioral observation at rest during three minutes and 30 seconds.

The hello song was sometimes entrained to breathing rate with P1 and P4, but for the most part, a well-known song was used to initiate the session, this decision was made because during baseline assessment participants either did not show wakefulness issues or the hello song entrained to breathing rate increased sleepiness in P1. More information about this issue was provided in the discussion. Sessions were video-recorded and scored in the MATADOC by the researcher based on the observations of the video. The final MATADOC outcome and scoring were based on the official MATADOC guidelines (Magee, Lenton-Smith, & Daveson, 2015).

Auditory Simulated Presence Therapy

On a single session and during no more than 30 minutes, recorded verbal messages from loved ones were supplied to the participants either by headphones or speakers and after verbally informing the participants what was about to happen. The researcher previously divided the audio files in several chunks of different length (from 10 seconds to four minutes) and interacted verbally in between the audios, validating the participant, and attempting to follow-up with the message and if needed assist them to connect with the stimuli. The whole condition length ranged between 23 to 28 minutes and 37 seconds and depended on the length of the total recorded messages and the amount of verbal interaction with the participants.

Recorded Songs

On a single session and during an average of 29 minutes, and a range of 22 to 35 minutes, recorded songs were supplied through headphones or speakers, and after verbally informing the participants about it. In between each song the researcher followed-up with verbal questions related to the song and validation statements to increase the response of the participant. The songs used were identified in an interview with the significant loved one using open-ended questions and the Music Therapy Patient Profile and Preference Questionnaire (MTPPPQ) provided in the MATADOC guidelines (Magee, Lenton-Smith, & Daveson, 2015). For some participants additional music and songs were included based on cultural characteristics of the sample and discussed with loved ones of the participants.

Live Music Therapy

The sessions lasted no more than 30 minutes, and the session was developed from identified strengths and needs during the MATADOC baseline. Active music therapy applications were elaborated by the researcher and individualized for each participant. The goals set were to increase response to verbal commands, active engagement, verbalization, long-term and short-term memory, fine and gross motor control, and other goals further described in each case. However, one of the four participants were sleeping during the session and a receptive approach was used with her to increase arousal and wakefulness. Preferred songs were sung a capella, hummed, or accompanied with guitar, and occasionally included the name of the patient, and paired with gentle tapping and touch of hands. Only live music was used, and active techniques included instrument playing, reading music, following verbal commands to music, singing, keyboard improvisation, and rhythmic stimulation like playing the drum to the beat of a song sung by the researcher. Other strategies used are further described in each case.

MATADOC as Post-Test

A single MATADOC session was performed immediately after each condition to track changes in awareness levels in the MATADOC scores. The protocol used was the same used during the baseline. The scores and findings were compared with baseline and between the other conditions.

Video Recording

All sessions were video-recorded and then analyzed by the researcher identifying changes in behaviors during the conditions and the MATADOC sessions.

Materials

The materials that were used in the research were: one, the Music Therapy Patient Profile and Preference Questionnaire (MTPPPQ). Two, official MATADOC scoring documents. Three, a camera to record each session and assist with data collection. Four, an audio recorder to capture the voices of the relatives. Five, a computer with an audio editor (Audacity) to edit and compile the voices and recorded songs. Six, headphones and HD sound and bass speakers. Seven, digital playlists with favorite/familiar music. Eight, musical instruments: guitar, tambourine, egg shakers, buffalo drum with a mallet, and keyboard. Nine, music scores to assess reading of music with P1and P4.

Data Analysis

The data collected included the MATADOC scores and findings, video recordings of each session, and an open interview with caregivers. The scores and the qualitative information provided by the MATADOC was compared mostly within each subject, but also within the group during the baseline phase. The videos were first written in narration form (see appendix B to E) and then charted identifying the appearance or absence of any noteworthy behavior and or theme, and in some few cases frequency of behaviors and themes was also collected. Caregivers reports were transcribed and summarized. All these data were labeled with the initial of the participants, and stored in a private computer with two passwords, one at the start of the computer and the other one in the folder that contained the data.

Protection of Human Subjects

This study was approved by the Institutional Review Board of Illinois State University as an expedited study. Although this study had a low risk of harm, to mitigate any other risk of emotional or physical distress a questionnaire to track appropriate preferred music was given for the relatives to complete. Then, the researcher selected the music that had a more positive message to be used during the conditions. If a client showed signs of distress (face grimacing, agitation) the music or the recorded messages was immediately stopped, like in the case of P2 undergoing listening of recorded songs. The benefits for the participants included the possibility of having increased arousal, and for the caregivers, the assessment could provide important information about the participant's current sensory awareness levels.

CHAPTER IV: RESULTS

The purpose of this chapter is to present the results of the four participants in this exploratory study case that evaluated the use of the MATADOC, and the behavioral responses of the musical and non-musical auditory stimulation with patients with advanced dementia. The participants are presented separately and in six parts, consisting in a general description of the participant, followed by the MATADOC summary of the baseline findings. Then, a summary of the observed responses of the participant during and after each condition, measured both by the MATADOC single/session and the behavioral/thematic analysis, with the visualization of the data through Figures1 through 4 and Tables 3 through 10. This is followed by an analysis of the three compared stimuli and an evaluation of the MATADOC for the participant based on both clinical knowledge and experience. Caregiver's reports are presented after this.

Finally, once the four cases are presented, Figures 5 and 6, and Tables 11, 12, and 13 provide a visualization of the compared data: MATADOC diagnostic scores of section one, MATADOC baseline total results, analysis of the MATADOC findings, behaviors and themes that appeared during the session, and caregiver's reports. Most of the data was notated and scored after the session by the researcher and with the observation of the video recordings of the sessions and the audio recording of the caregivers. The transcriptions of the sessions and the total MATADOC reports for each participant can be find in Appendixes B, C, D, and E.

Case 1 - P1

Description

P1 was an 82 years old female with both diagnoses of dementia and Alzheimer´s Dementia according to the facility chart. She was widowed, living in a nursing home, and under hospice care. She received frequent visits from two daughters, grandchildren, and great-grandchildren, and she occasionally recognized her daughters. In the facility she used to do crafts, walk, and participate in music sessions but not anymore. During the day in the nursing home she remained seated in a wheelchair in a hall and attended some social events like mass participating rather passively. She received full assistance in all ADLs but was able to eat on her own simple solids with supervision. Most of her expressive language and comprehensive language functioned at a severely impaired level, and she appeared almost non-verbal. Nevertheless, she retained some non-verbal communication like using smiles and she was still able to shake her hand back to say hello if cued.

MATADOC Baseline Results

MATADOC outcomes indicate that P1 is responding at a Minimal Conscious State (MCS) level. She demonstrated awareness of herself and her environment, but it was inconsistent throughout the four sessions.

Comparing the pre-observational period with the post-observational period is highly probable that the protocol on itself had an overall arousal effect on P1, as sleeping behaviors were most commonly observed before the protocol, and not usually after.

During the assessment she showed many strengths within a musical environment such as retrieving words and melodies from well-known songs through humming and singing, matching the same pitch of the assessor when singing, communicating non-verbally through eye contact and face expressions with the music therapist, connecting the body towards a purpose like playing a simple instrument with upper extremities, responding with emotions to music through smiling and laughing, maintaining attention to task, and working with an environment to produce intentional meaningful behavior like singing. It is noteworthy that her responses could be increasingly successful if well-known songs are used and receiving assistance such as visual cues (modeling), tactile stimulation, and hand-over-hand assistance. For example, her response to verbal commands was much more appropriate when the command was embedded in music. The command "sing with me" in the middle of a song was followed consistently engaging her in singing. The command "clap your hands" and "clap faster" was followed appropriately after training it with visual, musical, and tactile cues during the second session.

In conclusion, as part of her hospice care music therapy would be recommended to work on maintaining cognitive, spiritual, emotional, physical, and social areas, and including the family to further connect with her. This could be highly beneficial for her quality of life and her loved ones.

Summary of Responses During and After the Conditions

A comparative list of behaviors and themes observed for P1 during the three conditions are presented in Table 3. Figure 1 shows the MATADOC post-test scores of P1 after the three conditions and the baseline for comparative use. Table 4 shows the numerical MATADOC scores of P1 graphed in Figure 1. Afterward, a narrative description of behaviors and findings on each condition and MATADOC post-test responses for P1 are presented.

Table 3

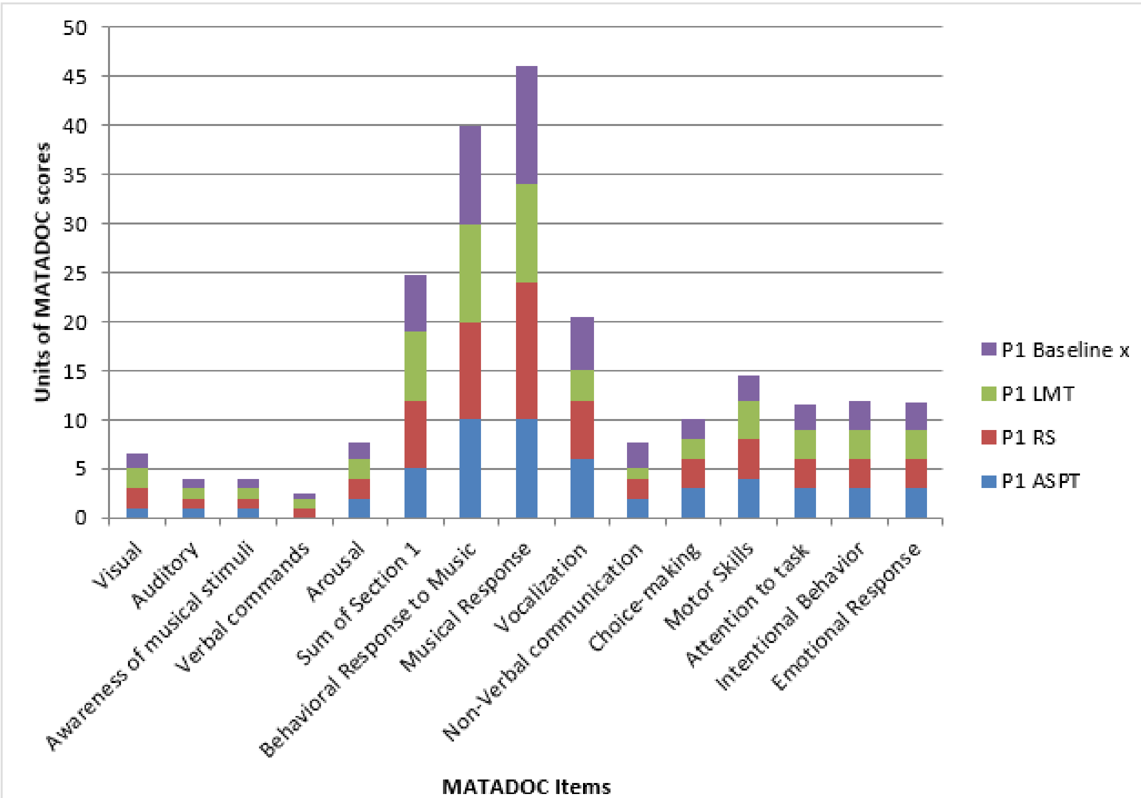
Behavioral/Thematic Analysis of the Three Conditions Studied for P1

P1			
Behaviors/themes	**ASPT**	**RS**	**LMT**
Laughing	X	X	X
Smiling	X	X	X
Foot tapping		X	X
Humming		X	X
Sing lyrics			X
Nodding		X	X
Verbal interaction	X	X	X
Inconsistent engagement in conversation	X	X	
Chance of understanding of emotional words	X		
Active listening	X	X	X
Pragmatics	X	X	X
Active prosody in non-verbal speech	X	X	X
Intermittent sleeping	X		
Inconsistent engagement in long tasks	X		X
Social interaction	X	X	X
Arousal		X	X
Choice-making		X	
Followed verbal commands in music			X
Sustained attention		X	X
Verbalization of target words			X
Assisted eye-hand coordination			X
Maintained declarative musical memory		X	X
MATADOC: more behaviors at pre-observation	X	X	X
MATADOC: more behaviors at post-observation		X	X
MATADOC: sleeping at post-observation			X

Data explanation= Behaviors and themes were identified in each condition through video analysis. The X marks the presence of the behavior/theme under each condition and no X stands for an absence of the behavior/theme.

Figure 1

MATADOC Post-Tests for P1 After the Three Conditions and Compared to the Baseline Average



Data explanation= Comparison of the MATADOC post-test scores for P1 after LMT, RS, and ASPT, with the baseline average per each of the 14 items. Additionally, the comparison of scores of the sum of the Section 1 is also provided. The numbers in the y axis correspond to the number of units of MATADOC scores. Specific score numbers can be observed in Table 4.

Table 4

MATADOC Post-Test Scores of P1 After the Three Conditions and Compared to the Baseline Average

MATADOC Items	ASPT	RS	LMT	Baseline x
Visual	1	2	2	1.5
Auditory	1	1	1	1
Awareness of musical stimuli	1	1	1	1
Verbal commands	0	1	1	0.5
Arousal	2	2	2	1.75
Sum of Section 1	5	7	7	5.75
Behavioral response to music	10	10	10	10
Musical response	10	14	10	12
Vocalization	6	6	3	5.5
Non-verbal communication	2	2	1	2.75
Choice-making	3	3	2	2
Motor skills	4	4	4	2.5
Attention to task	3	3	3	2.5
Intentional behavior	3	3	3	3
Emotional response	3	3	3	2.75

Data explanation= MATADOC post-test scores of P1 after LMT, RS, and ASPT, with the baseline average shown in the far-right column. The numbers in this table corresponds with the visualization in Figure 1.

Auditory Simulated Presence Therapy. Active listening to the audio, with interactive verbal and behavioral responses; intermittent sleeping; appropriate pragmatics of conversation with the researcher during follow-up questions.

Summary of Changes in the MATADOC After Auditory Simulated Presence Therapy Plus Visit from Loved Ones. Just when the pre-observation part of the MATADOC had started, P1 received visits from her daughter, her son-in-law and her granddaughter. The procedure had to be interrupted and continued after the visit. Therefore, the evaluation included also a 15-minute visit from loved ones. There were no significant changes in the MATADOC scores, however, there were behavioral changes in the post-observation at rest. P1 showed increased visual tracking, arousal, engagement of the body, and an increased number of physical movements. These could be the effects of the preceding stimuli plus the stimuli provided by the protocol.

Recorded Songs. Active music listening with verbal and behavioral responses; arousal, she stayed awake despite being sleepy and even with sedative music; choice-making, she chose between two verbal options of artists; Inconsistent engagement in brief conversation periods.

Summary of Changes in The MATADOC After Recorded Songs. No different responses from baseline. She achieved the highest score within her baseline, but the same diagnostic outcome.

Live Music Therapy. Maintained memory for well-known melodies. She would follow either humming, or singing the actual parts of the lyrics of the songs, and with increased success if assisted with the researcher singing and leaving blank spaces for her to fill in. Vocalization of specific target words following the pitch of the researcher. She filled-in singing cued target words, however, the attempts to transfer these words to spoken form were inconsistently successful. Increased response to verbal commands within a musical environment. As observed during the MATADOC, commands within the music such as "sing with me" were followed well, or verbal commands with verbal, visual or tactile cues were more successful too. However, she followed verbal commands inconsistently when the musical elements were taken out. Arousal. She stayed engaged the whole session, although needing occasional cues to keep her engaged on a task like calling her name, prompting her to look at the researcher, or making changes in the music. It appeared that her responses decayed towards the end of the session and towards the end of a task that was long, for example, her eye contact was consistent during the first application that lasted two minutes, and inconsistent in the second application that lasted more than six minutes.

Summary of Changes in the MATADOC After Live Music Therapy. No different responses from baseline. However, she did respond highly within her baseline.

Comparison of Stimuli

None of the three stimuli increased MATADOC scores compared to the baseline, but recorded songs (RS) and live music therapy (LMT) stimuli obtained consistent higher scores compared to auditory simulated presence therapy (ASPT), which suggests that these stimuli increased her awareness level to her possible maximum. The main factor to this difference was found in visual responses that were consistent during both RS and LMT compared with ASPT + visit from loved ones. Responses to verbal commands were also higher after both musical conditions. The three stimuli produced a high score in arousal. This arousal effect could be also observed by comparing the responses at rest between the baseline and the conditions. P1 stayed awake during the three pre-observations at rest, whereas without stimulation she usually slept. However, the appearance of behaviors and the amount of them observed after LMT suggested more awareness and sense of self than the other two (eyes tracking in all directions, verbalization, changes in facial expression). Paradoxically, the music therapy post-observation period, which means after the stimuli and the MATADOC protocol, was the only one where P1 fell asleep. While the post-observational period after ASPT+ visit of loved ones showed more arousal behaviors in both quantity and quality (body movements like wanting to get out of the chair, initiation of interaction, eyes tracking in all directions). This confirms the arousal effect of the protocol, but also suggests a fatigue effect after 50 minutes of active musical stimulation, pointing to an optimal amount to increase arousal.

Evaluating the MATADOC for P1

MATADOC was able to find awareness deficits in P1 enough to set her in a diagnosis of Minimal Conscious State. Even though the name does not match a category of dementia, it shows some correspondence with CDR and GDS severity. Therefore, an important finding is that MATADOC can identify signs of low awareness in a person with severe dementia and very severe cognitive decline like P1. At the same time the MATADOC identified strengths, a high response to music and improved cognitive function but it was not tracked by the tool. The tool could be adjusted to the population with dementia regarding the classification of names and assessing areas more relevant for the dementia population.

One suggestion for a revised version of the MATADOC to fit dementia is to include evaluation of memory through musical tasks. This way should differentiate and include sensory, short-term, and long-term memory, and musical memory. As observed, her declarative musical memory was highly maintained in P1, through reproducing melodies and lyrics. She also showed increased response to verbal commands embedded in the music. These responses could be used to show increased awareness and strengths.

Another change that could include a MATADOC to assess patients with dementia could be to define which type of cue, or assistance is more effective to increase the response of patients. Considering that cognitive deficits such as attention, memory, and executive function might be at the root of low awareness levels of a person with dementia, it would be beneficial to know which different types of prompts and assistance improve these levels. In the case of P1 it was observed that different types of prompts and cues improved their success during certain tasks: visual (modeling, pointing), tactile (touching), auditory (calling her name), musical cues (include silences within the music), and hand-over-hand assistance.

Other changes that could be included to fit the dementia population is to include responses to tactile stimulation. As P1 showed increased responsiveness using instruments that provide tactile feedback like shakers.

In the auditory awareness responses, it was observed that P1 turned her head very little times towards the stimuli, but responded with other behaviors such as vocalizations, laughing, moving away from the source, and changing her facial expression. These behaviors could be considered or not to show positive auditory responses.

The emotional response is another area to be considered. In the case of P1 many times she responded with laughs and smiles, like when meeting with the researcher, when a song ended, to isolated sounds, or during verbal interactions. Some few responses were not appropriate to the stimuli however, many others were appropriate. The researcher suggests that including the wording "consistently responds with appropriate emotional behaviors" could be more effective to track differences within this category.

Finally, add more space to write down information, and a checkbox to see if the patient uses a wheelchair or not could be minor changes that could be included to meet the patients with severe dementia.

Caregivers' Reports

One caregiver was interviewed in the fourth session. She said that P1 was "happier yesterday, more engaged, had conversations, more upbeat, and laughing", that she asked her about liking the music and that she responded "yeah". She said that "the music made her a lot happier", that she was not "grumpy" and that this happiness "lasted until the night".

The daughter of P1 was interviewed after her visit during the recorded messages stimuli and she said: "I saw her a little bit different today, she seems more alert, and put some more words together, that some still don´t make sense, but put together words that she usually doesn´t". She said that she asked her mother if she remembered the recorded stories that she just heard, but she did not. Her granddaughter said, "Granma is doing better".

In the same session, another caregiver was interviewed, and she said that she did not observe any changes in the usual behaviors of P1. She said that she usually stayed calm, and interacted through smiles, but that it was not common to see her laugh.

After the second MATADOC session, it was common to see P1 laughing when she engaged in the first eye contact with the researcher to begin the sessions. Her caregiver said that P1 was happy. This laughing response could point to an emotional memory of P1connecting the researcher with a happy situation.

Case 2 – P2

Description

P2 was a 97 years old female, widowed, and she was living in an assisted facility within the memory care unit. She was diagnosed with Alzheimer´s Disease, and five years ago her state worsened after hospitalization due to repeated hip fracture that occurred three consecutive times. For this reason, she was wheelchair-bound and had to be moved to a nursing home. She presented aging-related tremors that also started five years ago. She presented no hearing on her right side due to the cutting of her acoustic nerve after Meniere's Disease. For some time, she was in hospice care but then taken out since she did not meet the criteria to be terminally ill.

In the nursing home, she spent her days with no significant active functions otherwise that attending to mass on Sundays and to some recreational activities, where she participated passively. When she was in the halls of the nursing home, she liked to have a doll with her, and she interacted with it by talking and cuddling. She was also visited weekly by a catholic couple that gave her the sacrament when asked they said that P2 did not connect with them cognitively.

When she was met by the researcher, she was confused but talkative and recalled many memories from her distant past, her Irish heritage, and she initiated conversation through questions. Her answers to questions were sometimes disconnected to the original question, and it was difficult to understand, because her speech was slow, stuttering, and had a frequent cough that impeded the flow. She also showed a constant tremor on her jaw. When she was asked if she liked music, she said that she liked it, and she mentioned that she had music lessons in school, that she did not want to play by then, and that she had two pianos.

MATADOC Baseline Results

MATADOC outcomes indicate that P2 was responding at a higher-level state of awareness. She demonstrated consistent awareness of herself and her environment, and only slightly diminished in her ability to track auditory stimuli in the absence of visual or tactile cues.

Comparing the pre-observational period with the post-observational a trend to increase talking behaviors was observed after the protocol, but no other significant changes were observed.

During the assessment, she showed a high ability to visually track more than one stimulus presented at the same time, consistent interactive responses within musical exchange when playing instruments like the keyboard or the drum, high response to verbal commands and high arousal. She showed responses to different elements of music like melody, rhythm, dynamics, timbre, form, and tempo, that produced behavioral responses like smiling, maintain and switch eye contact, fill-in words, move her upper extremities, and increase her arousal through increased talkativeness. She showed some ability to recall words of well-known songs, high response in non-verbal communication through hand gestures and head nodding, ability to make choices between two objects, purposeful movement of upper extremities, high attention to musical tasks, intentional behaviors like singing and playing music, and emotional responses through smiling and verbally stating her liking of music.

In conclusion, P2 did not show deficits in awareness, therefore her cognitive deficits should be addressed to other areas most probably to orientation to reality, short-term memory, lexical memory, and hearing loss. Her high responses in a musical context suggest that music therapy is highly recommended to work on maintaining her cognitive, spiritual, emotional, physical, and social areas. Including her family to further connect with her could be highly beneficial too to improve her quality of life and from her loved ones.

Summary of Responses During and After the Conditions

A comparative list of behaviors and themes observed for P2 during the three conditions are presented in Table 5. Figure 2 shows the MATADOC post-test scores of P2 after the three conditions and the baseline for comparative use. Table 6 shows the numerical MATADOC scores of P2 graphed in Figure 2. Afterward, a narrative description of behaviors and findings on each condition and MATADOC post-test responses for P2 are presented.

Table 5

Behavioral/Thematic Analysis of the Three Conditions Studied for P2

P2			
Behaviors/themes	**ASPT**	**RS**	**LMT**
Verbal interaction	X	X	X
Active listening	X	X	X
Pragmatics	X	X	X
Verbalizations modeled by the form of the music		X	X
Nodding		X	X
Social interaction	X	X	X
Arousal	X	X	X
Autobiographical memory retrieval	X (11:6A,5S)	X (1S)	X (10:8S,2A)
Connection to reality/control		X	X
Declarative sensory memory		X	X
Emotional verbal response		X	
Smiling	X (2)		X (5)
Laughing	X		X
Working memory during Q&A	X (32%)		X (79%)
More appropriate verbal answers when the song was identified			X
Sustained attention	X	X	X
Headphones risk		X	
Episodic memory	X		
Hearing impairment	X	X	X

(Table Continues)

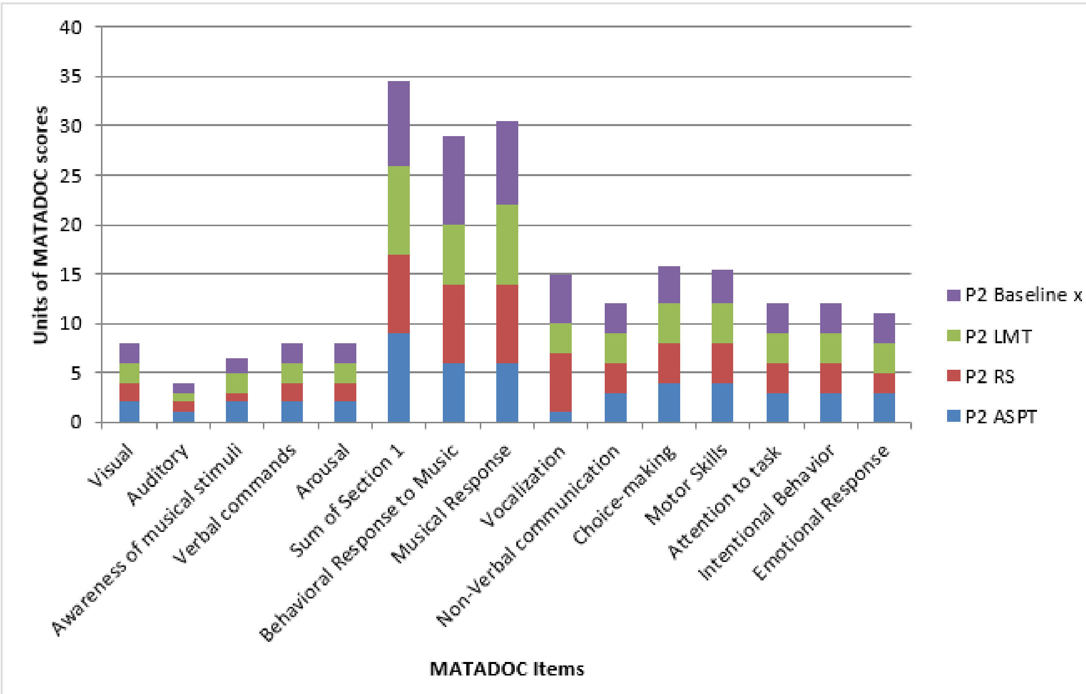
Table 5, Continues

P2			
Behaviors/themes	**ASPT**	**RS**	**LMT**
Semantic priming	X		X
Consistent musical interaction reflecting maintained cognitive resources			X
Reading and singing showed good access to long-term memory (SAL)			X
Singing lyrics			X
Repetition needed to access long-term musical memory			X
MATADOC: No sleeping or talking behaviors at rest, rather active behaviors	X	X	X
MATADOC: Lower scores on musical interaction and mood		X	
MATADOC: Only verbal vocalizations, unrelated to musical stimuli	X		
MATADOC: Inconsistent vocal sounds to musical stimuli, only hummed			X

Data explanation= Behaviors and themes were identified in each condition through video analysis. The X marks the presence of the behavior/theme under each condition and no X stands for an absence of the behavior/theme. Number in parenthesis provide frequency of behaviors. In the case of the autobiographic memory retrieval behavior A stands for assisted and S for spontaneous. In the case of the working memory during Q&A (questions and answers) refers to the verbal follow in between auditory stimulations, and the percentage indicates appropriate answers to questions. SAL stands for semantic, autobiographic and lexical memory.

Figure 2

MATADOC Post-Tests for P2 After the Three Conditions and Compared to the Baseline Average



Data explanation= Comparative graph of the MATADOC post-test scores for P2 after LMT, RS, and ASPT, with the baseline average per each of the 14 items. Additionally, the comparison of scores of the sum of the section one is also provided. The numbers in the y axis correspond to number of units of MATADOC scores. Specific score numbers can be observed in Table 6.

Table 6

MATADOC Post-Test Scores of P2 After the Three Conditions and Compared to the Baseline Average

MATADOC Items	ASPT	RS	LMT	Baseline x
Visual	2	2	2	2
Auditory	1	1	1	1
Awareness of musical stimuli	2	1	2	1.5
Verbal commands	2	2	2	2
Arousal	2	2	2	2
Sum of section 1	9	8	9	8.5
Behavioral response to music	6	8	6	9
Musical response	6	8	8	8.5
Vocalization	1	6	3	5
Non-verbal communication	3	3	3	3
Choice-making	4	4	4	3.75
Motor skills	4	4	4	3.5
Attention to task	3	3	3	3
Intentional behavior	3	3	3	3
Emotional response	3	2	3	3

Data explanation= MATADOC post-test scores of P2 after LMT, RS, and ASPT, with the baseline average shown in the far-right column. The numbers in this table corresponds with the visualization in Figure 2.

Recorded songs. Autobiographical memory was achieved through one spontaneous reminisced memory, where she partially recalled a memory with one of the songs "Too Ra Loo Ra Loo Ra Loo Ral". Connection to reality and control was achieved in three occasions, through two statements of telling that the music was too loud, and one follow-up saying that the level was better. Emotional responses were achieved on one occasion, when she said, "That was beautiful", after listening to "I´ve Been Working on The Railroad". Verbal interaction was achieved through a total of eight pairs of questions from the researcher and answers from the participant, both appropriate and not. From this total, six were either "no", "I don't know", or unrelated answer and only two were connected to the question. Working memory was achieved in six times, through two appropriate answers that revealed relevant content and connection to the question, two statements of telling that the music was too loud, and one follow-up from her, saying that the volume was better. The form of the music, through the ending of a song or the end of a musical phrase, modeled most of the verbalizations that she elaborated. Sustained attention was maintained throughout the 23 minutes of the session. One negative effect was that listening to music with headphones increased her levels of stress by decreasing her ability to connect with others during an attack of chronic cough. At the same time, the continued music stimulus during the coughing could have overstimulated her, in a moment where she needed to be comforted and soothed. Coughing was a behavior seen many times during the baseline, and it was easily managed by stopping the music and offering her water. However, this time, as she had the headphones and the music was on, she was unable to hear or look at the researcher that was already offering her the cup of water. In conclusion, recorded songs show positive effects in social interaction, sustained attention, slight effects over autobiographical and working memory, and one negative effect due to isolation from headphones.

Summary of Changes in the MATADOC After Auditory Simulated Presence Therapy. No changes in score or final awareness level. Some lower scores but within minimums reached during baseline. Less duration of interactive musical awareness. The only score different from baseline was on emotional response, where she only showed one change. These changes could be due to the reduced duration of the session and the negative effects of the cough attack before the session.

Auditory Simulated Presence Therapy. P2 listened in silence all the recorded messages and followed up answering all the questions, sometimes making sense, but many times not. A total of 28 pairs of questions and answers were counted during the session, which of them, nine were appropriate answers, and 19 were either "no", "I don´t know", unclear answers, or answers unrelated to the question. Autobiographical memories were achieved in 11 times, which of them six were assisted, and five were spontaneous. The assisted ones consisted of that the researcher presented the memory and she only said yes, and these were: the name of her horse, the name of her friend, her main job, when she met with her husband, and the name of the high school she attended. One more assisted memory was achieved by giving her options to tell the number of her children. While the spontaneous memories were the description of how she met with her husband, the religious state of her friend, her size, that she attended church dinners, and that nuns were good. The description of how she met with her husband had at least seven different ideas, while the other four memories were made from a simple one-single idea. Working memory was achieved on nine occasions through appropriate answers to the questions. Some answers started connected to the question, but they develop unclearly and were not counted. For example, on both occasions when she talked about her retirement since she only stated the first idea correctly, but the following ideas were not clear or connected to the first one. Episodic memory was achieved in one occasion through localizing the city where she attended high school. Emotional responses were achieved in one time through smiling. Her ability to answer questions appropriately and retrieve memories showed a trend to increase gradually after each message.

A general effect of semantic priming was generally observed when she incorporated parts of the message into her verbalizations. This was observed when she talked about her retirement when she talked to the doll and said that she was a little snob and the verbalizations of her last message that included a pool of three memories triggered by a general statement of her 97 years old.

In conclusion, auditory simulated presence therapy showed positive responses in verbal interaction, sustained attention, and autobiographic memory. Partial responses on working memory through verbal interaction, semantic priming, and episodic memory.

Summary of Changes in the MATADOC After Auditory Simulated Presence Therapy. No relevant changes from baseline. The only change was that she did not vocalize or filled-in the blank of songs, however, she did interact verbally as usual. Maybe because the repertoire was mostly new, except for "KKK Katy", and on another occasion, she did not fill in the blank with that song either.

Live Music Therapy. Working memory was worked through questions and answers. A total of 19 questions were made by the researcher, which 15 of the answers from P2 were appropriate and connected to the question, and four were not appropriate for the question made. Working memory was also worked during music playing with the song *"When Irish Eyes Are Smiling"*. She showed consistent interactive musical changes within the musical exchange. She changed her way of playing the egg shaker to match the tempo of the guitar, she followed silences introduced in the song by stopping and playing in four different occasions, she matched the final ritardando, and the last chords of the song. She played for a total duration of 1 minute 40 seconds. Altogether these behaviors showed not only good working memory, but high awareness of musical stimuli, good attention skills, good executive functions, and upper extremity control. Reading and singing were also used to train her working memory and to access lexical and semantic memory. The song "Oh Danny Boy" was presented using lyrics, and "My Wild Irish Rose" was used using both lyrics and musical scores. She showed a good ability to read despite her slow rate, and even when she was not reading, she sustained her gaze to what the researcher was pointing in the paper. In both cases, she showed a dramatic increase in singing words compared to baseline. During "When Irish Eyes Are Smiling" she read five words corresponding to the title; with "Oh Danny Boy" she read 21 words and sang 26 words, and with "My Wild Irish Rose" she read and sang at the same time nine words. With "I've Been Working on The Railroad" she sang 33 words without reading. Therefore, she trained lexical memory through a total of 94 words, and semantic memory with at least 15 different concepts that were involved in these lyrics. Interestingly, most of the time she did not recognize the song immediately and repetitions were needed for her to recognize it. In the case of "My Wild Irish Rose", she needed three repetitions to access long-term memory. With “I've Been Working on The Railroad" singing the melody first with a single syllable, then adding the lyrics were also useful for her to recognize the song. On the other hand, "My favorite things" was played only once, and it was not recognized, and at the same time, this application accounted for two of the four answers not connected to the question. Probably, the music could influence semantic priming, not achieved when the song was not recognized. Autobiographical memory was achieved through a total of 10 memories reminisced, which eight memories were retrieved without assistance, and two with assistance from the researcher. In these two last cases, the researcher offered her the statement and she agreed. Social interaction was developed throughout the music therapy session, not only through verbal interaction but also through non-verbal communication achieved through music-making. Her sustained eye contact with the researcher during musical tasks, the fact that almost all her answers were connected to the questions during verbal interaction, and her musical performance that showed high awareness during instrument playing, suggested high levels of sustained attention. Emotional responses were observed on seven occasions, including five smiles and two laughs. In conclusion, P2 showed positive changes during music therapy on the areas of working memory, long-term memory (lexical memory, semantic memory, autobiographical), sustained attention, executive function, verbal interaction, and upper extremity control.

Summary of Changes in the MATADOC After Live Music Therapy. No relevant changes from baseline. Vocalization responses were again the most different response. However, this same response was observed during the second session of the baseline.

Comparison of Stimuli

None of the three stimuli produced changes in the MATADOC and there was no change in the diagnostic outcome of the MATADOC since P2 had already scored a high level of awareness. Therefore, the stimuli were analyzed in terms of changes in long-term memory (autobiographical, episodic, semantic, lexical), working memory, emotional responses, and sustained attention.

All the three stimuli showed positive and similar effects over sustained attention, as she remained engaged throughout the sessions with the three stimuli. In verbal interactions, ASPT showed the greater number of pairs of questions and answers with 28, followed by music therapy with 19, and recorded songs with wight. However, LMT showed greater on-task answers, addressed to increases in working memory, with 15 answers, followed by ASPT with 9, and last RS with two on-task answers. But this could be influenced because the researcher learned to speak better by talking to her good side and stressing the higher pitch consonants by the end when the LMT condition occurred. Autobiographical memory showed similar responses between ASPT and LMT, but LMT showed a greater number of memories retrieved without assistance. LMT stimulated 10 memories (eight spontaneous and two assisted), while ASPT stimulated 11 memories (five spontaneous and six assisted). RS only elicited one autobiographical memory, but this was also highly affected by the cough incident. Episodic memory was only retrieved once during ASPT. Semantic memory was elicited more with LMT through songs, with 15 different ideas, followed by 11 different ideas during ASPT, and eight different ideas during recorded songs. Both LMT and ASPT showed high effects on lexical memory, through increased access to words. During LMT she showed 94 words only during reading and singing (but not including the verbal interactions), followed by ASPT with 110 words through verbal interaction, and recorded songs with 58 words. Emotional responses were more frequent during LMT with seven responses (five smiles and two laughs), followed by ASPT with three smiles, and RS with one smile. Additionally, LMT showed positive effects over upper extremity control and executive function. While RS showed effects on exert of control through requesting to decrease the volume of the music.

Evaluating the MATADOC for P2

MATADOC was able to tell the awareness level of the participant, showing that she achieved a high-level state. Therefore, dementia has not affected her ability to perceive her environment and her deficits should be addressed to other areas such as orientation to reality, cognitive processing, and hearing loss. This means, that these areas could be included in a version of the assessment tailored to the dementia population. At the same time, MATADOC showed several strengths that could help to plan future interventions. But again, it did not assess typical areas that are usually used by the geriatric population to compensate for damaged areas, in connection with selective and optimization strategies.

One addition could be to include an assessment of reading. Reading is one of the simplest cognitive tasks and facilitates access to lexical and semantic memory. As observed in P2's case, this ability was unimpaired and dramatically increased her verbalization of target words compared to baseline.

A second point to evaluate would be related to the "responses to auditory stimuli". It was observed that P2 inconsistently turned her head to auditory stimuli, and only responded if the sound was accompanied by a verbal command or calling her name. However, is she was asked she would be able to say if she listened to the sound or not, and with an increased success if the stimuli were provided by herself. None of these procedures are described in the official guidelines of the MATADOC but could be included to better assess this area of function.

A third addition could be to include a simple hearing test before the session to increase the success of her responses. It was observed that P2 not only did not hear from one side, but she also presented hearing loss on both high and low frequencies, observed during verbal commands, and requesting her to discriminate between high and low sounds produced by the tone bell. Hearing responses could be evaluated by a simple test before the beginning of the assessment and considering these losses, to make adaptations, usually improved function of patients with dementia.

Another addition could be to checkmark if repetition is needed to access musical declarative memory as P2 showed. Even though the guidelines suggest repeating the music to increase recognition with DOC, with dementia it could be defined and informed.

Lastly, an ideal addition would be to include a cognitive section that could assess sensory, working, long-term memory, executive function, and orientation to reality, within a musical environment. As observed in P2, and connected with the reviewed literature, she was able to access to autobiographical memory, and working memory, on her own, with more success with LMT than the other two conditions. Including these areas could show clear memory strengths in a musical environment despite the severity of dementia. It would also challenge other assessments and provide support for non-pharmacological cognitive stimulation treatment for people with dementia through music therapy.

Caregivers' Reports

It was not possible to obtain much information from caregivers, due to rotation and inability to engage in contact with the persons that worked in the facility close with the patient.

Case 3 – P3

Description

P3 was an 81 years old male, married, a veteran of the army, and he lived at home with her spouse. He had one daughter and one son that lived in the same town with their own families. He was diagnosed with Alzheimer's Disease seven years ago. The first symptoms appeared about 10 years ago when he forgot to pay bills and attend to his job as postmaster, and since then symptoms gradually have gotten worse. Recently, his neurologist questioned the diagnosis of AD and ordered neuroimages to better assess the specific form of his dementia.

He was assisted for ADLs, for example, to pick up his clothes properly and put it right, or to eat socially appropriately, as he was recently eating hand food like burgers or bread toasts with fork and knife. He showed low awareness in a way that when her wife was sick, he did not show attention or cared for her. He showed low sensibility to pain, which affected his ability to communicate wounds and cuts. Recently, at night, his wife found blood on his sock and noticed he had injured his toenail, but he was unaware of it.

Co-morbidity of low vision on the left eye due to trauma; bilateral presbyopia; and bilateral presbyacusis. He had prescription glasses, but he did not use it often but hearing assistive devices were always used. History of prostate surgery to remove a tumor, with no need for radio or chemotherapy. His speech showed deficits such as forgetfulness of words, interrupted speech flow, agrammatism, and the content was poor like low use of vocabulary, and repeatedly told the same stories. Additionally, he showed no motor impairments and he was able to walk on his own without any difficulties.

At home, he spent his days watching TV and accompanying his wife to different errands and social activities, such as shopping, mass, and parties. During the day he tended to wander through the living room, kitchen, and hall of his house. He stored small items in a small bag, such as coins, fridge magnets, chocolates, and candies. Many times, he gave away some of these items to kids that he met, and when this bag was lost, he started opening drawers and taking out objects to find it.

Six years ago, he developed an "extreme" liking for music. His wife stated that he did not own records, although he used to enjoy music normally. When he heard any type of music, and especially rock, he smiled, sang loud, clapped, danced, and moved to the music. Interestingly, his singing lacked coherent words, but it was highly energetic. Also, when he had nothing to do, like waiting, he sang short motifs like "doo bee doo bee doo bee doop" or he drummed on a table. These changes made him a candidate for musicophilia.

MATADOC Baseline Results

MATADOC outcomes indicate that P3 was consistently responding at a higher-level state of awareness and did not show signs of disorders of consciousness. He demonstrated awareness of himself and his environment achieving the highest score in all assessed items, except for vocalization, where despite being verbal, he showed a low number of words verbalized during song singing.

Comparing the pre-observational with the post-observational periods a trend to produce more musical behaviors were observed in the post-observational part in sessions one and three. While sessions two and four were not performed with him at rest, as his wife intervened talking with the assessor and P3, affecting his attention and responses. At the same time, the musical behaviors observed could be, on one hand, an effect of the musical stimulation provided during the protocol, but also it could be a sign of elevated mood, especially considering the dramatic change of affect in session three.

During the assessment he showed consistent and high ability to visually track more than one stimulus presented at the same time, to track auditory stimuli, to respond interactively within a musical exchange and especially when playing instruments, high response to verbal commands and high arousal. He showed responses to different elements of music like melody, rhythm, dynamics, timbre, form, and tempo. These elements of music produced behavioral responses in his face expression like smiling, maintaining and switching eye contact, promoting singing mumbled words, filling-in specific words in a song, improvise melodies using his voice with simple syllables, and move purposefully upper extremities to make music. He showed ability to recall some words of well-known songs; high use of non-verbal communication through hand gestures, head nodding, and interactive eye contact; ability to make choices between two objects; purposeful movement of upper extremities in musical tasks like instrument playing; high attention to musical tasks, intentional behaviors like singing and playing music; and emotional responses through smiling, laughing, and verbal comments of music liking.

In conclusion, P3 did not show deficits in awareness, and his cognitive deficits should be addressed to other areas most probably to as memory, orientation, executive functioning, speech, and information processing. His high response in a musical context suggests that music therapy is highly recommended to work on maintaining his cognitive, spiritual, emotional, physical, and social areas. Noteworthy is the effect of music stimulation to improve his mood, especially through an active application such as improvisation and music playing, but also just by listening to the music. Although, not official, since there are currently no official guidelines, it is my opinion that P3 shows signs of musicophilia based on: sudden onset of increased musical liking consistent with time of dementia; the person appears to be highly animated with music stimulation based on increased appearance and frequency of physical, emotional and musical behaviors. Hedonic changes and specifically with music have been reported to be far more common in patients with frontotemporal dementia and not so much with Alzheimer's disease. Therefore, this could support a differential diagnosis and point to a more adequate treatment. At the same time, this increased love for music makes him a perfect match for music therapy treatments and they could be developed to increase and maintain emotional, physical, cognitive, and social skills. Most importantly music could enhance the connection with loved ones and this most likely would positively impact the quality of life of P3 and his loved ones.

Summary of Responses During and After the Conditions

A comparative list of behaviors and themes observed for P3 during the three conditions are presented in Table 7. Figure 3 shows the MATADOC post-test scores of P3 after the three conditions and the baseline for comparative use. Table 8 shows the numerical MATADOC scores of P3 graphed in Figure 3. Afterward, a narrative description of behaviors and findings on each condition and MATADOC post-test responses for P3 are presented.

Table 7

Behavioral/Thematic Analysis of The Three Conditions Studied for P3

P3			
Behaviors/themes	**ASPT**	**RS**	**LMT**
Verbal interaction	X	X	X
Active listening	X	X	X
Pragmatics	X	X	X
Appeared to be talking on the phone	X		
Low ability to retrieve what was listened	X	X	X
Semantic priming	X		
Reminiscing triggered by the act of listening	X		
Laughing	X	X	X
Increased mood and number of positive behaviors reflecting happiness		X	X
Interactions with music as a source of reality		X	X

(Table Continues)

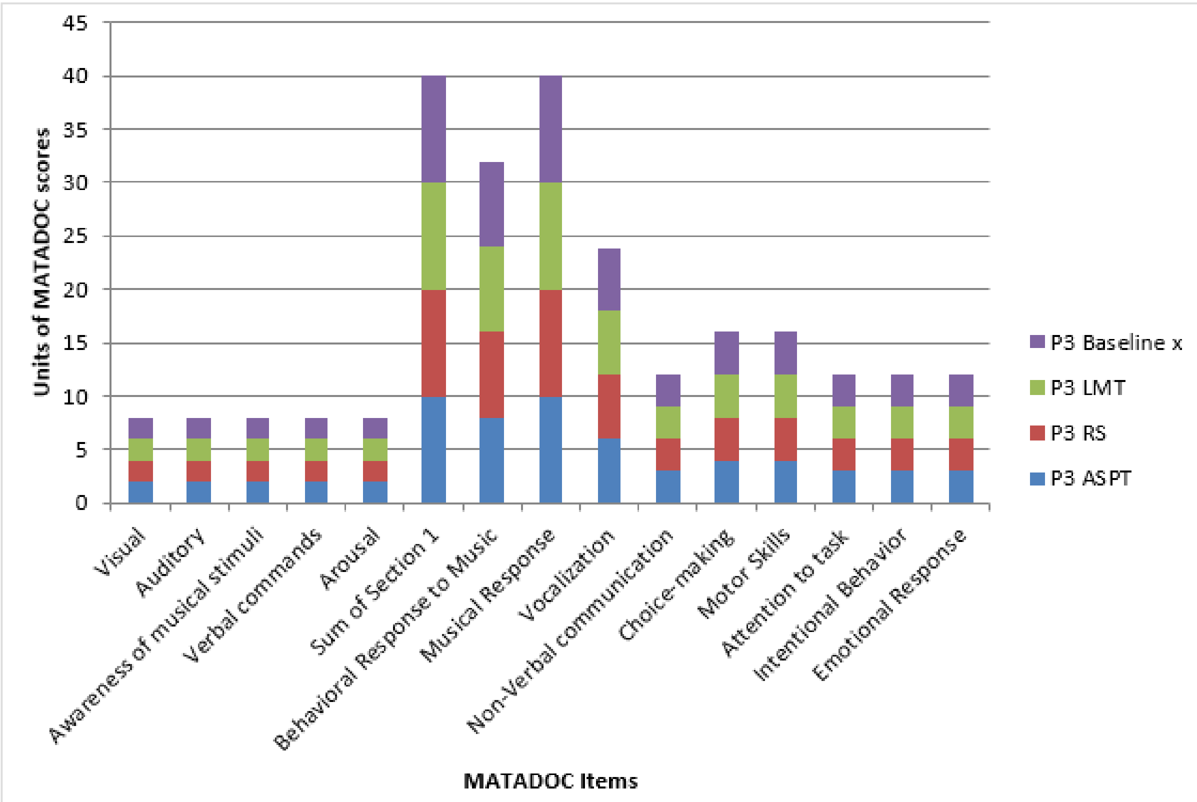
(Table 7, Continues)

P3			
Behaviors/themes	**ASPT**	**RS**	**LMT**
Singing without words, rather improvise melodies or reminisce military cadences		X	
Increased number of target words achieved through reading. His performance progressively decreased with less assistance.			X
Improved pitch and rhythm when singing during training with guitar and reading			X
Positive reinforcements had effects on positive mood.	X	X	X
Social interaction	X	X	X
Arousal	X	X	X
MATADOC: Positive mood behaviors in both pre and post-observation at rest	X		
MATADOC: Pre observation showed initiation of verbal interaction with assessor, musical and positive mood behaviors, while post did not.		X	X
MATADOC: In the pre-observation, he talked about music, and with assistance answered correctly questions related to the session.		X	
MATADOC: Did not track changes in improved vocalization, words, and rhythm			X

Data explanation= Behaviors and themes were identified in each condition through video analysis. The X marks the presence of the behavior/theme under each condition and no X stands for an absence of the behavior/theme during a certain condition.

Figure 3

MATADOC Post-Tests for P3 After the Three Conditions and Compared to the Baseline Average



Data explanation= Comparative graph of the MATADOC post-test scores for P3 after LMT, RS, and ASPT, with the baseline average per each of the 14 items. Additionally, the comparison of scores of the Sum of the Section 1 is also provided. The numbers in the y axis correspond to number of units of MATADOC scores. Specific score numbers can be observed in Table 8.

Table 8

MATADOC Post-Test Scores of P3 After the Three Conditions and Compared to the Baseline Average

MATADOC Items	ASPT	RS	LMT	Baseline x
Visual	2	2	2	2
Auditory	2	2	2	2
Awareness of musical stimuli	2	2	2	2
Verbal commands	2	2	2	2
Arousal	2	2	2	2
Sum of section 1	10	10	10	10
Behavioral response to music	8	8	8	8
Musical response	10	10	10	10
Vocalization	6	6	6	5.75
Non-verbal communication	3	3	3	3
Choice-making	4	4	4	4
Motor skills	4	4	4	4
Attention to task	3	3	3	3
Intentional behavior	3	3	3	3
Emotional response	3	3	3	3

Data explanation= MATADOC post-test scores of P2 after LMT, RS, and ASPT, with the baseline average shown in the far-right column. The numbers in this table corresponds with the visualization in Figure 5.

Live Music Therapy. The most relevant effect of the session was the increased number of target words he achieved through reading. Both songs were assessed during the baseline, and in those opportunities, he was able to sing no more than four words in each song. When he sang reading, he achieved consistently 100% accuracy of words, although needing partial assistance to keep attention to the line where he was singing. His pitch and rhythm also improved when singing accompanied by the guitar, probably as a natural effect of entrainment to the pitch and harmony produced by the guitar. Unsurprisingly, his performance progressively decreased with less assistance, which means that he correctly articulated slightly fewer words when he read on his own, without pointing the words, and then fewer words when he had to sing by rote memory. Nevertheless, when he sang *"Can't Stop Falling in Love"* without reading, he still was able to recall words much more than baseline, and this was more effective for the first two verses than the chorus or even the last verse, which was equal to baseline. These results showed the effects of learning and retention of information. It also provides support to the use of written support to enhance the interaction of patients with moderate to severe cognitive decline during therapy, which is consistent with evidence and compensation strategies of aging. The condition also had positive effects on mood, based on observable behaviors such as laughing and smiling. Positive reinforcement after achievements triggered positive mood responses on him too.

Summary of Changes in the MATADOC After Live Music Therapy. No changes in final awareness level or internal scores, as he already had reached the maximum. Although some changes were observed in the vocalization area regarding an increased number of words retrieved, and a more accurate rhythm, MATADOC was not sensitive enough to capture these changes.

Recorded Songs. The most noteworthy effects were observable in mood responses, observed in many behaviors like laughing, smiling, movements of the body, positive verbal statements, and prompting high fives and thumbs up throughout the session. Musical behaviors such as singing, clapping, tapping chest, and tongue slaps also suggested signs of elevated mood. Interactions with music as a source of reality. He usually matched the tempo and dynamics of the music presented with clapping, singing, and body movement. But the melodies and musical phrases were inconsistently followed with his singing. Few verbalizations of correct target words of no more than four words were achieved on each song in "Walking After Midnight" (1), "Jailhouse Rock" (1), "Hit The Road Jack" (3), and "Georgia On My Mind" (5). He tended to sing using simple syllables, mumbling, and unarticulated syllables and vowels. Noteworthy was to find that he tended to sing the melody of a popular military cadence when presented with upbeat songs like "Sweet Home Alabama", "Hit the Road Jack", and "Back in The USA". Low identification of the artists after the audio. He identified Patsy Cline, Ray Charles, and Elvis Presley, with options, and not consistently. At the same time, the correct option was usually at the end, therefore, it was not possible to check if he was just repeating the last word or identifying the artist. However, he did acknowledge to know two songs by saying "I knew that one" after listening to “Sweet Home Alabama” and “Georgia On My Mind”.

Summary of Changes in the MATADOC After Recorded Songs. No changes from baseline.

Auditory Simulated Presence Therapy. P3 showed active listening behaviors based on his facial expression when he listened to the voice of his wife, and the verbalizations during the listening task. He repeated back words that called his attention in five out of eight messages. In all the messages he said agreement words like yes, ok, and right. On one occasion he provided a full speech of 59 words after listening to the second message. In general, he appeared to be actively talking with someone over the phone. He showed low ability to recall on his own what he just listened to when asked by the researcher. However, a general idea remained based on general answers given by him such as when he said: "That was a story, that was just, between, me, her, and me" after he listened about his honeymoon trip with his wife; or when he talked about people being separated and how he could not bring his family to the war, after the message about when he went back to Vietnam for the first time; or in the two other occasions where he talked about the Air Force after the messages mentioned Vietnam.

At the same time, he also brought up memories unrelated to the messages like after the second message when he talked about being with friends and telling jokes. Or when he talked about his father fixing radios, after asking him if he was enjoying listening to the stories. This memory appeared to be related to the procedure of listening as he used to listen to the radio with his father. He answered a total of 25 questions about the messages, 14 of them were correct, and 11 were incorrect. Unsurprisingly, he was more successful in answering questions from the message when options were given to him. Despite showing disorientation he mentioned the four cardinal points, but his wife mentioned that he always said them in the same order. Therefore, this appeared to be a learned phrase, and it did not imply increased orientation, as he mentioned that California was to the north. The intervention provided a set up for a conversation based on real facts of his life, and he appeared to enjoy the moment. He laughed at least seven times listening to the messages and talking with the researcher, in spite that his answers were not always correct.

Summary of Changes in the MATADOC After Auditory Simulated Presence Therapy. No changes from baseline.

Comparison of Stimuli

None of the interventions produced changes in the MATADOC scores, as he had already achieved the highest score in most of the assessed areas. The only impaired item vocalization did not track changes. The three stimuli offered a set up for social interaction where the participant was able to actively participate in the tasks through listening and speaking. The three stimuli produced increases in mood, but recorded messages elicited a higher amount of behaviors, followed by music therapy, and finally, recorded messages. However, some behaviors observed during song recording were not always connected to the specifics of the stimuli, like singing other melodies and no words. All these behaviors were also observed during song presentations in the MATADOC protocol, and less during instrument playing. Reminiscence behaviors were observed more during ASPT, although not all memories were connected to real memories. RS showed one memory reminisced and LMT no memories reminisced.

LMT achieved higher levels of cognitive function through increased access to lexical memory, working memory, articulation of words, and orientation to reality, through reading and singing lyrics of songs, compared to the other two stimuli. P3 verbalized and sang words 100% accurately when reading. Then, he was still able to recall some of the words, the melody, and form, and these changes, although with decreased effect, appeared during the MATADOC post-test but were not tracked. All these behaviors suggest increased connection to reality, as the participant was singing accurately connected to the songs, and they could be considered signs of increased awareness as his behaviors were more connected to the stimuli compared with the two other conditions. At the same time, the fact that these changes remained provides evidence for retention of information and learning, and therefore, it could show the way for the treatment of speech outcomes.

Evaluating the MATADOC for P3

MATADOC was able to show that P3 was functioning at a higher-level state. This means that he was aware of his surroundings and could interact with it appropriately. However, the lack of awareness in patients with dementia is seen not only in their abilities to interact with the environment, but also in their abilities to act appropriately in relation with a given social or cognitive context, like answering to a question on-task, acting with care when someone is sick, or reminiscing a memory which is truly connected to their life. In this regard, a scale tailored to patients with dementia should cover the areas of memory, mood, verbalization, orientation to reality, appropriate social behaviors, and empathy. Nevertheless, this scale in its current form is useful to show that the patient is aware of his surroundings and can interact with it appropriately, regardless of his verbal functioning level.

In the item of auditory responses P3 sometimes showed where the sound was by pointing with his hand appropriately. Currently, this response is not considered in the MATADOC manual but as it was always accurate, it should be incorporated when working with patients with dementia. Conversely, P3 few times attempted to localize the sound by saying "right" or "left", but these responses should not be considered valid, as he sometimes said the name of one side, but pointed and turned to the other side.

In the vocalization item, the responses of P3 sometimes appeared to be in between attempted words and verbalizing the last cued word. As described, he sang mumbling words, simple syllables, and unarticulated syllables, and occasionally a few correct words in one song. An intermediate level could be included in the MATADOC to acknowledge that the patient sang very few clear words, not always at the end of a phrase, and mumbled sounds but not attempting to sing actual words.

In the area of choice-making, P3 was able to show a preference between two objects. Therefore, the researcher attempted a higher level of question, asking him to pick options between something that just occurred to assess short-term memory.

To start the session with P3, a well-known song that matched his mood was presented to him. As the participant did not show wakefulness problems, playing a hello song matched to the breathing rate appeared odd and inappropriate for his functioning state. This way to start a session is well-used by music therapists working with geriatric populations and it should be considered when working with patients without wakefulness deficits.

In the verbal commands area, P3 functioned at a high-level, for that reason, to assess patients with moderate dementia, more complex commands could be included, for example, assess two-step directions like hold the drum and strike it with a mallet.

During periods of rest, P3 was sometimes talkative, and even when the researcher was behind him, he still rotated his head and initiated a conversation with him, or with his wife, or with her caregiver. The content of this interaction could be included, and the possibility for the assessor to answer and maintain a conversation if the patient initiates it should be considered too. The type and increased quantity and quality of behaviors in response to music could be considered to identify musicophilia. MATADOC already tracked these responses very accurately, but there are no norms or scores about when a person could be considered to have musicophilia. Additionally, it appeared that a simple hearing test could be performed before starting the MATADOC to check for hearing loss and responses in the different frequencies.

Caregivers' Reports

In the second to last session of the intervention, his hired caregiver reported the following: "I think that music keeps him happier. I also see him more connected. For example, when I ask him to help me with something, he does it with more pleasure and joy, unlike other days that he does it more for being a gentleman than with initiative. When he listens to music during the day, he is also happy, he speaks alone, and even sometimes tells stories. But I see it more when you come because it is more about the connection from person to person that makes him want to talk more. After you leave it's like he wants to integrate into the group, when I and her wife are talking. I have seen him happier when you are playing music with him, and he knows that you are coming to play with him. And that is more emotional too. When he listens to music, in general, he is happy, but someone needs to be there. I have also seen this when I start dancing with him".

In the last session, his wife said: "He's happier since the music sessions, sometimes he shows problems to get dressed and now it's not the case". She was asked to rate the degree of change from one to ten, and she said "I will say been like seven in terms of connectivity, the physical response of his face, how he reacts when you ask him a question. I am very grateful, very grateful. I think these last days there was not much negativity, quite the contrary, he has been following my directions. Like staying seated or I tell him that we are going to change clothes, for example, and before it was no, no, no, but these days phenomenal! I tell him we are going to take a walk, and he stands up without asking anything, and he is already singing and, he sings a lot. Another change I have seen is when he watches TV. Normally, the television is turned on and he is looking at it, but today he was watching, and he was listening too!".

To sum up it appears that caregivers mentioned different positive effects of the intervention, including increased mood (happier, joyful), increased awareness (connectivity, facial response, reaction to questions, listening to TV), increased social participation (integration), increased compliance (getting dressed, going for a walk, less negativity). These behaviors were seen after the session. Additionally, his spouse rated high the level of change, with a number seven from one to ten, and mentioned to be grateful for the intervention. Therefore, the changes in the patient could also have a positive effect on the primary caregiver's quality of life.

Case 4 – P4

Description

P4 was a 71-year-old female, former biology teacher, and married to a Christian pastor. She was diagnosed with vascular dementia after having a right stroke 6 months ago, which left her with a hemiparetic flaccid left side, wheelchair-bound, social maladaptive behaviors, memory loss, and overall dementia. When she was met, she talked with a monotone voice and showed a flat affect, and possibly and emotional dysprosody. She and her husband were brought to the nursing home after her stroke since her siblings lived out of town and no one was able to take care of them. She was very devoted to Christianity and as a hobby, she used to read hymns and Christian music on the organ.

In the nursing home, she spent days sitting in a wheelchair in the halls of the memory unit. She did not attend social leisure activities because she did not behave well. She did not even attend the dining room to eat with the rest of the residents, because on prior occasions she started yelling and making other residents uncomfortable. On the other hand, she met and talked with her husband daily.

MATADOC Baseline Results

The MATADOC outcomes indicate that P4 was consistently responding at a Higher-Level State of awareness. She demonstrated awareness of herself and her environment although sleeping behaviors partially interrupted her arousal. This affected sometimes her ability to interact fully with the music. However, she was easily awakened to function and respond to the musical tasks and showing ability and awareness of the spaces provided for her to play and interact.

Comparing the pre and post observational periods no changes were observed. She appeared very talkative in the first session, and progressively fewer behaviors were seen in the next ones, to the point where sleeping behaviors were seen in sessions 3 and 4 in both pre and post observations.

During the assessment, she showed the ability to track more than one visual stimuli, consistently localize auditory stimuli, interact within the musical exchange, follow verbal commands, and stay awake during most of the session. She showed responses to elements of the music like rhythm, melody, tempo, timbre, and form, which triggered responses in her eye direction, vocalization, and physical movements. She vocalized all of the words of familiar songs showing good long-term musical memory, communicated with appropriate non-verbal communication, made choices between two objects, showed purposeful movement of right upper extremity through instrument playing, ability to attend to musical with intermittent sleepiness, ability to produce intentional behaviors seen in instrument playing, choice-making, score reading, identification of musical artists and instruments, and low emotional response observed only in two out of four sessions.

In conclusion, P4 did not show deficits in awareness, therefore her cognitive deficits should be addressed to other areas most probably to orientation to reality, short-term memory, executive function, mood disorders, and arousal. Her high responses in a musical context suggest that music therapy was highly recommended to work on maintaining her cognitive, spiritual, emotional, physical, and social areas. Including her family to further connect with her could be highly beneficial too to improve her quality of life and from her loved ones.

Summary of Responses During and After the Conditions

A comparative list of behaviors and themes observed for P4 during the three conditions are presented in Table 9. Figure 4 shows the MATADOC post-test scores of P4 after the three conditions and the baseline for comparative use. Table 10 shows the numerical MATADOC scores of P4 graphed in Figure 4. Afterward, a narrative description of behaviors and findings on each condition and MATADOC post-test responses for P4 are presented.

Table 9

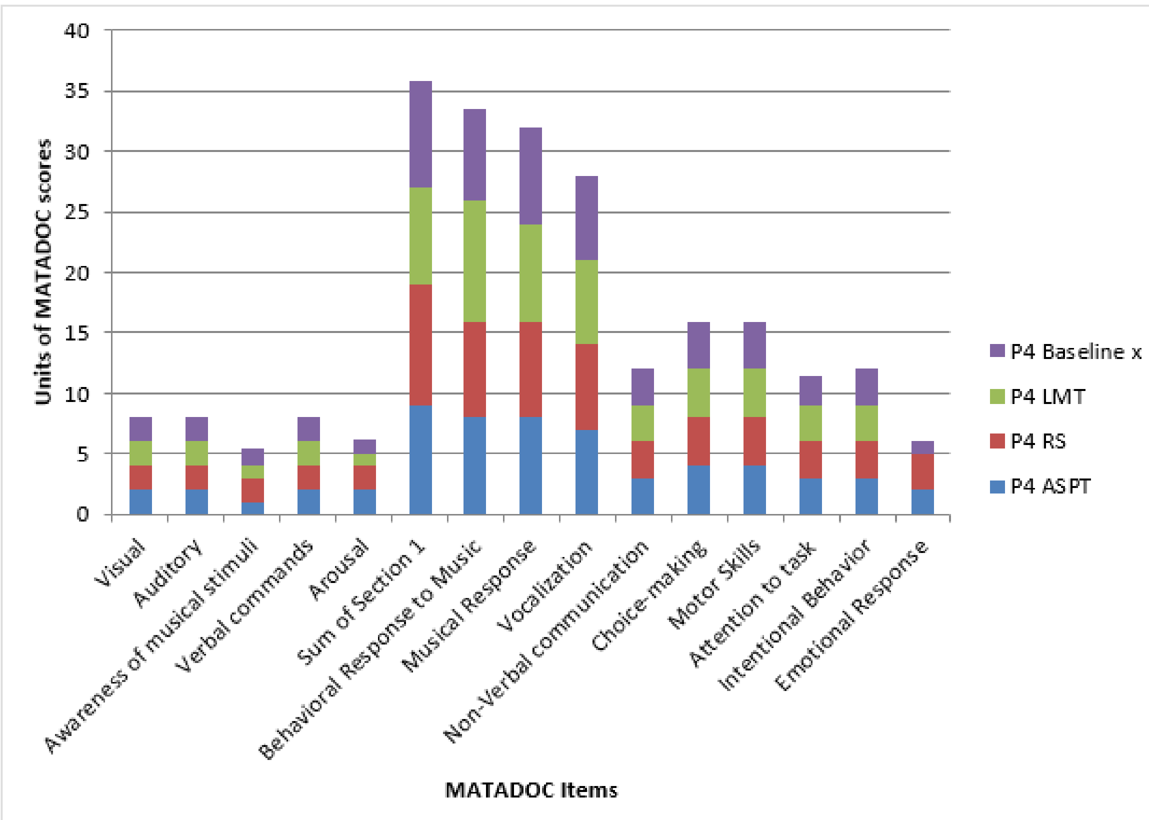
Behavioral/Thematic Analysis of The Three Conditions Studied for P4

P4			
Behaviors/themes	**ASPT**	**RS**	**LMT**
Verbal interaction	X	X	
Active listening	X	X	
Pragmatics	X	X	
Awareness of source of sound and music	X	X	
Ability to share memories and insights on the audio	X	X	
Sense of control	X	X	
Good access to long-term memory	X	X	
Difficulties to retrieve her age in the memories	X		
Good working memory during Q&A but mixed final stories	X		
Positive mood behaviors (smiling, laughing)		X	
Social interaction	X	X	
Sleeping			X
Physical responses entrained to the music			X
Soft vocalizations during presented songs			X
Partial arousal effects			X
MATADOC: Talks to the assessor at rest, on pre but not post	X		
MATADOC: Talks to the assessor on both pre and post		X	
MATADOC: Positive mood behaviors in the protocol		X	
MATADOC: Maximum score within the baseline		X	
MATADOC: Hello song entrained to BR increased total wakefulness			X
MATADOC: Scores of low arousal and inconsistent musical exchange			X

Data explanation= Behaviors and themes were identified in each condition through video analysis. The X marks the presence of the behavior/theme under each condition and no X stands for an absence of the behavior/theme.

Figure 4

MATADOC Post-Test for P4 After the Three Conditions with the Baseline Average



Data explanation= Comparative graph of the MATADOC post-test scores for P3 after LMT, RS, and ASPT, with the baseline average per each of the 14 items. Additionally, the comparison of scores of the Sum of Section 1 is also provided. The numbers in the y axis correspond to number of units of MATADOC scores. Specific score numbers can be observed in Table 10.

Table 10

MATADOC Post-Test Scores of P4 After the Three Conditions Compared to Baseline Average

MATADOC Items	ASPT	RS	LMT	Baseline x
Visual	2	2	2	2
Auditory	2	2	2	2
Awareness of musical stimuli	1	2	1	1.5
Verbal commands	2	2	2	2
Arousal	2	2	1	1.25
Sum of section 1	9	10	8	8.75
Behavioral response to music	8	8	10	7.5
Musical response	8	8	8	8
Vocalization	7	7	7	7
Non-verbal communication	3	3	3	3
Choice-making	4	4	4	4
Motor skills	4	4	4	4
Attention to task	3	3	3	2.5
Intentional behavior	3	3	3	3
Emotional Response	2	3	0	1

Data explanation= MATADOC post-test scores of P2 after LMT, RS, and ASPT, with the baseline average shown in the far-right column. The numbers in this table corresponds with the visualization in Figure 4.

Auditory Simulated Presence Therapy. The stimuli had a positive effect on social interaction. P4 actively engaged in continuous conversation with the researcher answering questions and making comments about the memories told by her loved one. She also exerted some sense of control when she agreed to continue listening to more messages, every time the researcher asked her if she wanted to listen to the next one. Long-term memory (lexical, semantic, autobiographical) was trained during the stimuli. She used many different words within her conversation, showing an ample range of lexical memory, as observed in the baseline. She reminisced with all the memories shared and provided more information about each one, even correcting information to the researcher. She identified the persons in the recordings by their voice and described different elements of the message and memories when she was asked. However, it appeared to have difficulties in localizing the age of her and others in time. Short-term memory was trained through the conversation as she had to keep in her mind the topic and answer questions related to the memory. For the most part, she showed a good ability to maintain a logical conversation throughout the procedure. However, towards the end of the fourth message, she mixed the stories and talked about birds that were on the third message. At the same time, words were not as clear as before, and the message could not be fully interpreted. As usual on her, she did not show emotional facial expressions, even when some of the stories were acknowledged by her to be funny or surprising.

Summary of Changes in the MATADOC After Auditory Simulated Presence Therapy. No relevant changes from baseline.

Live Music Therapy. It was not possible to provide an active approach because she was sleeping during the session. A receptive approach of presenting familiar songs, paired with gentle tapping and touch of hands was used. The stimuli had positive effects over physical responses such as movements of the right hand and left leg. The movement of the right hand did not appear to be fully consciously mediated, but it showed entrainment to the beat of the music. While the movement of the left leg appeared to be connected to the fast-simulative music played by the researcher, it was not well-synchronized with the tempo. She vocalized most of the words from the songs presented, but with a very soft almost inaudible voice. She vocalized these words with her eyes closed. The whole procedure had partial effects over increasing arousal, considering that at the end she started opening her eyes, she followed prompts of deep breathing, and moved her head. However, she remained with her eyes closed.

Summary of Changes in the MATADOC After Live Music Therapy. Same score than baseline. However, changes in arousal appeared within the item behavioral responses to music, as this was the first time that she started MATADOC sleeping. Additionally, she was awakened with the hello song procedure of the MATADOC. This is a specific technique to initiate the protocol that consists of breathing with the patient aloud, introducing single notes paired with these breathes, adding progressively chords and intervals with the voice, and improvising simple melodies with the name of the participant and the word "Hello". The assessor also sang prompts like "open your eyes", and "it´s time for music".

Recorded Songs. The condition had positive effects over social interaction with the researcher, through answering questions and making comments about the songs and the questions. She trained and showed access to long-term memory (lexical, semantic, and autobiographic). She used an ample range of vocabulary and grammar to provide her answers. She described places and identified artists of the songs presented with facilitation through cues provided by the researcher. She reminisced memories through questions made by the researcher and provided details about those memories. She showed elevated mood signs through smiling and laughing on 4 occasions. Two of those responses occurred after she guessed the name of the artist, which was assisted with cues, and then positively reinforced with a high five. Another one was when she was asked about how she did the song "Let Me Call You Sweetheart" make her feel, and she said it was a song about sweethearts. She laughed and smiled after the researcher did. The last time she laughed and smiled within the same song follow-up, where she answered "You are getting pretty personal" after the researcher asked her who was her current sweetheart.

Summary of Changes in the MATADOC After Recorded Songs. No changes in the diagnostic outcome score from baseline. However, it was remarkable that she did achieve a maximum score of 10, which appeared only in the first assessment session of the baseline. The most noteworthy change was in the emotional response item. For the first time, she showed several emotional behaviors during the protocol. The fact that she also showed these behaviors during the stimuli condition suggests positive effects of the intervention with recording songs on mood, which at the same time, could have enhanced her overall cognitive function, and consequently increasing her response in the musical awareness item.

Comparison of Stimuli

The LMT stimulus could not be equally compared to the other two since the alertness state of P4 was low in the music therapy condition, and the goal was to increase her arousal instead of increasing her emotional response. Therefore, only RS can be fairly compared to ASPT. Nevertheless, P4 was awakened after the LMT condition at the beginning of the MATADOC procedure, being able to achieve a score in the levels of her baseline. Therefore, some sort of comparison could be done using the three conditions after the MATADOC.

Both RS and ASPT had positive effects over social interaction with the researcher, long-term memory access (autobiographical, lexical, semantic) and short-term memory function to maintain a conversation. The biggest difference was achieved in the RS condition, where she showed an unseen increase in her mood through facial expressions as signs of happiness. While in the recorded messages condition, even when she listened to funny messages, and she verbally stated about happy times and memories, her face and voice did not show those emotions. In the RS condition this was achieved through positive reinforcement after guessing the name of the artist of the song, and during dialogue following-up the song "Let Me Call You Sweetheart". This song had a clear emotional content that led the conversation towards feelings of love. In the end, those feelings and the dialogue were able to connect her to the expression of happiness through smiles and laughs.

The LMT condition aimed to increase the arousal state of P4 to wake her up. Through her responses during the condition, despite sleeping she was aware of her surroundings since she was vocalizing the words of the song, moving her right hand to the tempo of the music, and followed commands to take deep breaths. Towards the end of the condition, she started blinking and opening her eyes, but she closed them again and did not wake up.

Nevertheless, she did fully wake up during the initial hello song of the MATADOC protocol, opening her eyes wide open while looking to the ceiling. Her awakening was preceded by changes in her respiration pattern as soon as chords were paired to her breathing rate. This technique of hello song entrains the music to the breathing rate, and progressively layers musical elements in a very simple song. It was developed to wake up comatose patients with disorders of consciousness and have several cases that support its effects. Therefore, it could be possible that the MATADOC hello song technique had more power to wake the patient up. However, this cannot be proven. What most probably happened was that it was the sum of the stimuli and the hello song that had effects over increasing the arousal of P4, especially considering that she started blinking towards the end of the condition. Another argument that supports the positive effect of music therapy over increasing arousal is that during the MATADOC she fully attended to the tasks, and only slept during the first 4 minutes of the hello song. These facts contrast with sessions 3 and 4 of the baseline where deficits in arousal also affected attention to task.

All three MATADOC diagnostic scores of Section 1 were in the levels of P4's baseline, RS 10, ASPT 9, and LMT 8. However, RS not only achieved the highest score, but also a remarkable unique increase in the emotional responses item, unseen in the baseline and the other two conditions. This positively correlates with the elevated mood behaviors observed during the condition and shows that the effects remained after the condition. Also, the fact that the musical awareness item also increased could be due to the relation between mood and increased cognitive function. This could explain why she interacted more consistent in musical exchange, by improvising with the keyboard, creating melodies, and following the tempo and style of the assessor. Additionally, in both pre and post observational periods, she initiated a conversation with the assessor, suggesting increased awareness of the researcher in the room and supported the signs of elevated mood.

The fact that she obtained the highest score in both MATADOCs in the first assessment of the baseline and after the recorded song condition, that in both assessments she initiated verbal interaction with the researcher during the pre and post observational periods, and that in both she showed elevated mood responses, although higher during the condition, suggests that elevated mood increased her awareness levels.

On the other hand, the low scores in the MATADOC after LMT was consistent with the low alertness state of P4 during the condition, affecting the scores of arousal and musical awareness. In both ASPT and LMT conditions, she remained silent during the pre-observational periods, but in both post-observational periods she initiated a conversation with the researcher. This supports increased awareness of the researcher in the room and probably elevated mood after the protocol, and points to the MATADOC protocol on itself as a stimulus that increased the awareness levels of P4.

Evaluating the MATADOC for P4

MATADOC was able to track changes in P4's responses and showed variability in her scores throughout the four sessions, though not reaching a change in her diagnostic outcome, which was a higher level of awareness. Through the assessment, it was observable that her arousal levels, ability to produce consistent exchanges within the music interaction, attention to task, and emotional responses showed variability, while all the other items showed high scores and consistency throughout the four sessions.

The protocol was initiated with a familiar song that could trigger increased engagement, and a hello song paired to breathing rate when she showed low arousal. The MATADOC hello song technique after the music therapy condition produced relevant changes in respiration and arousal levels, and consequently fully waking up the patient. Previously the LMT condition was not able to accomplish this goal. This outcome provides support to the use of this technique in both the assessment and treatment of increased awareness in a person like P4.

P4 achieved high scores and consistent responses in the auditory item throughout the seven MATADOCs. However, she sometimes obtained 80% of responses, borderline with the over 75% threshold considered in the manual for consistent response. In the task of playing sounds with hand chimes or shakers to the sides of her ears, outside of her visual field, she sometimes appeared unresponsive and the command had to be repeated. She did not always turn her head but was able to point with her finger where the sound was, even though the assessor commanded her to turn her head to the sound. These behaviors, where she consistently pointed to the sound, but not turning her head, should be evaluated and considered when validating this scale with patients with dementia, as they might show some degree of impairment to respond to pure auditory stimuli.

In the area of awareness of musical stimuli, she showed variability to produce consistent musical exchange with musical instruments. However, with her voice, she showed way much more consistency. She always sang all the words matching the rhythm, form, and tempo with the assessor. She did not match dynamics with her voice and a few times she matched the pitch, but in her condition probably this was not possible due to dyspraxia after the stroke. When she was playing instruments, she showed consistent difficulties to stop the movement of her right hand even after a musical prompt where the assessor stopped playing. These behaviors could be more connected to difficulties in tactile proprioception, memory, and executive function than awareness of musical stimuli. However, the fact that she achieved the highest score in this item in assessment sessions one, four, and after the RS condition where she initiated verbal interaction in both observations at rest, and where she showed emotional responses, supports that her response playing instruments could be improved. The researcher suggested that including executive function, memory, touch sense, or manipulative dexterity in a scale validated for these populations could be beneficial to assess for confounding variables within the awareness of musical stimuli item. At the same time, it would beneficial to include responses to lyrics in the musical response item, as P4 showed high awareness of lyrics even in spoken non-sung form.

Another musical response that was not tracked by the MATADOC was the ability to read scores. P4 showed some retention of this ability and an emotional response to this task, observed in session 1. Maintaining this activity could be highly beneficial regarding cognitive and emotional areas of function, and it could show another area of musical awareness and a task for visual stimuli. Additionally, she showed some mild impairment in reading, as she skipped parts and only read accurately when the rhythm was simple with quarter notes. Considering that reading music is a skill developed only in few people with musical training, this could be an optional part of a future assessment, but highly informative.

P4 showed deficits in the attention to task item in the baseline sessions three and four. Her deficits in attention were affected when she slept in some parts of some tasks like hello song, song presentation, instrument playing, or closing song. She never slept during visual responses, auditory responses, choice-making, or verbal commands. She still participated in the tasks, but her arousal levels affected her attention. She attended for entire musical tasks, which is a Level 2, but at the same time, she attended for moments in musical tasks, which is a Level 1. Since the manual states to rate the highest level she scored a two. As patients with dementia are different from comatose patients and tend to have higher responses, the researcher felt that the options within the item did not quite fit the quality of attention that P4 was using. Even though the manual explains that the item broadly monitors attention and that "it is not suggested that music therapy can or should test for specific attention deficits" (Magee, Lenton-Smith, and Daveson, p.34, 2015), it would be beneficial with this population to evaluate further this area, especially considering that a music environment could increase attention.

Other areas that would be beneficial to assess on a scale that measures awareness for the dementia population, could include evaluation of cognitive functions such as orientation to reality, short-term memory, and long-term memory. For example, her verbal material produced during musical interaction was not captured and analyzed by the tool and could be highly informative regarding these mentioned areas.

Caregivers' Reports

No responses were possible to obtain due to the rotation of caregivers.

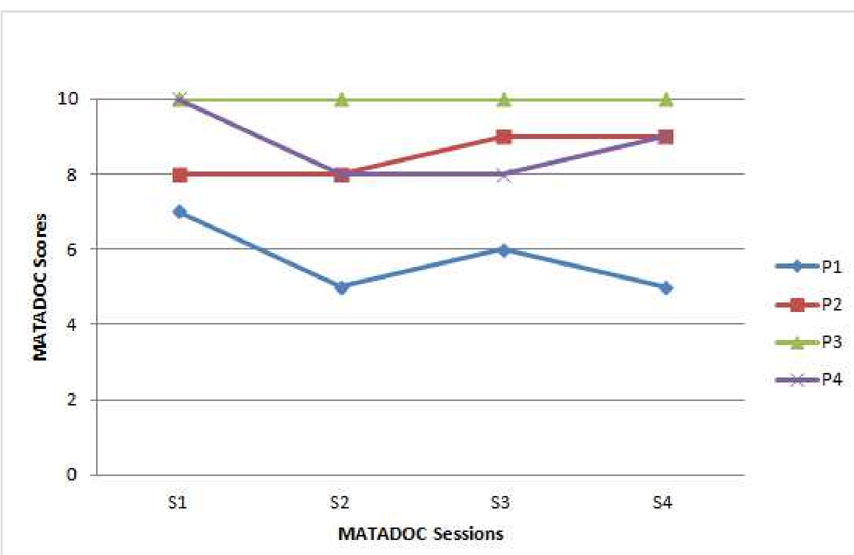
Compared Results

Compared MATADOC Baseline Results

Visualizations of compared results are presented in this section. Baseline MATADOC results are presented in Figures 5 and 6, and Tables 11 and 12. Figure 5 shows the baselines scores of the first five items of the MATADOC for the 4 participants of this study. Section 1 of the MATADOC is relevant since it is used to provide a diagnostic outcome about the level of consciousness of the assessed person. Figure 6 shows the MATADOC average scores and standard deviation (in brackets) of the four participants on each of the 14 items of the assessment. Table 11 provides a comparison of the MATADOC baseline descriptive findings per section and items for the four participants, including additional observed findings. Table 12 provides an observational collection of findings that were not covered within the MATADOC official descriptors but appeared as relevant findings by the researcher for the evaluation of the MATADOC for people with SSD.

Figure 5

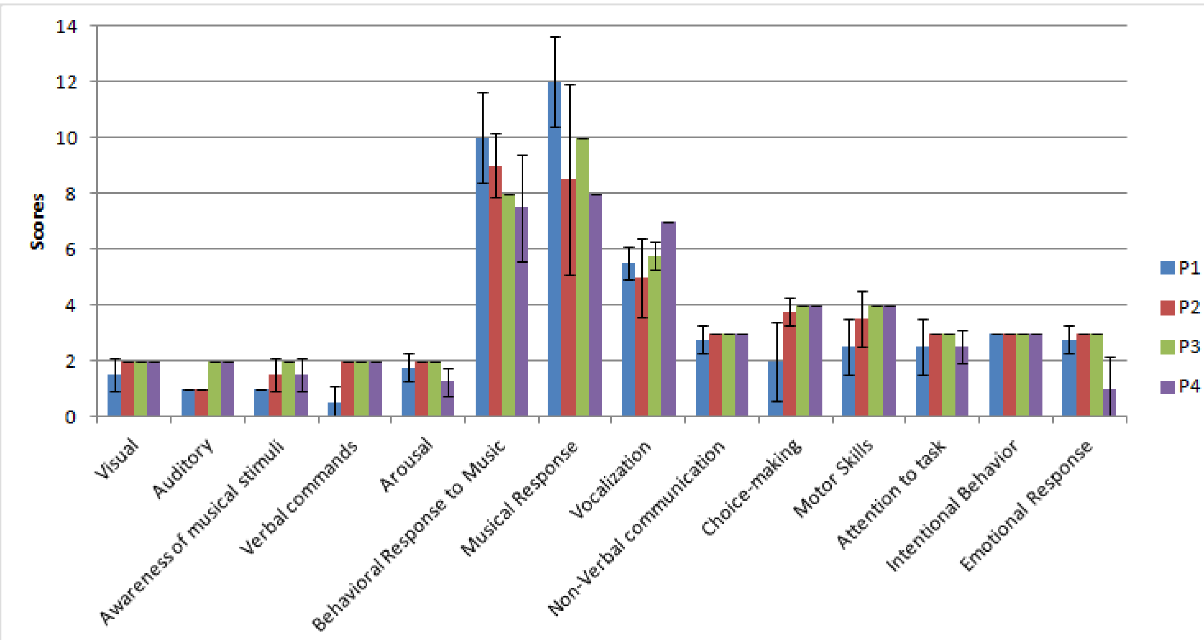
MATADOC Scores Section 1: Diagnostic Factors



Data explanation= Cumulative scores of the first five items of the MATADOC (visual responses, auditory responses, musical awareness, verbal commands, and arousal) per session. Each item had a possible maximum score of 2 and altogether a total maximum score of 1.

Figure 6

Baseline MATADOC Scores Per Item of the 4 Participants: Mean and Standard Deviation



Data explanation= Average scores of the four MATADOC baseline sessions per item are presented for P1 in blue, for P2 in red, for P3 in green, and for P4 in purple. The standard deviation is shown with a black line if it is 0 and with a bracket if it is more. The first five items compose the Section 1, they provide the diagnostic outcome and each item has a possible score between 0 and 2. The next two items make up Section 2 and while behavioral response to music has a possible score of 6 to 12, musical response has a possible score between 7 and 14. All the following items make up Section 3, they all have a possible minimum score of 0 but different maximums: vocalization 7; non-verbal communication, attention to task, intentional behavior, and emotional response 3; choice-making 5; and motor skills 4.

Table 11

Comparison of MATADOC Baseline Descriptive Findings Between the Four Participants

MATADOC outcomes	P1	P2	P3	P4
Baseline MATADOC diagnostic outcome	MCS (7,5,6,5)	Higher-level state (8,8,9,9)	Higher-level (10,10,10,10)	Higher-level (10,8,8,9)
Changes in pre to post observations at rest	Yes. Sleeping behaviors more common pre (4 out of 4) than post (1 out of 4).	Yes. Talking behaviors more common post (4 out of 4) than pre (2 out of 4). Talked to the assessor, with herself, and to doll. Sleeping behaviors only once in the pre-observation.	Yes. Positive mood and musical behaviors more present at post-observation. Initiated conversation with the assessor and recalled the session with assistance.	No changes identified. Talkative in session 1 and 2, and lethargic in sessions 3 and 4, pre and post. Initiated conversation with the assessor.
Findings of Section 1: Essential categories	Inconsistent tracking of visual stimuli. Improved with cues.	Consistent focus on more than 1 visual stimulus alternatively. Few times needing prompting.	Consistent focus on more than 1 visual stimulus alternatively. Less prompts.	Consistent focus on more than 1 visual stimulus alternatively. Less prompts.
	Inconsistent tracking of auditory stimuli. Other behavioral responses not included in the guidelines.	Inconsistent tracking of auditory stimuli. Impaired localizing, but other behavioral responses present. Deaf from one side, but able to localize if she played the shaker	Consistent localizing of auditory stimuli. Head-turning was achieved, but sometimes he pointed with his finger. Saying the word left or right was more inaccurate.	Consistent localizing of auditory stimuli. She turned head, pointed with a finger, and correctly said left and right.

(Table Continues)

Table 11, Continues

MATADOC outcomes	P1	P2	P3	P4
Findings of Section 1: Essential Categories	Interactive musical response but inconsistent. Singing she matched pitch, lyrics, and rhythm. When withdrawn, it improved with changes in the music.	Consistent and inconsistent interactive responses within the music. She improvised with keyboard and drum, matching duration and rhythm. With singing, she matched lyrics, tempo.	Consistent interactive responses within music interaction. Highly animated with music. Playing instruments was more musically successful than with singing.	Consistent and inconsistent interactive responses within the music.
	Inconsistent response to verbal commands. Musical commands were followed in musical tasks.	Consistently followed verbal commands. Hearing impairment affected comprehension, and tactile priming and repeating the command improved the response.	Consistently followed verbal commands.	Consistently followed verbal commands.
	More than 90% of arousal throughout 3 out of 4 sessions. Live music more effective than recorded. Familiar song better than hello song entrained to BR.	Consistently stayed aroused throughout the sessions.	Consistently stayed aroused throughout the sessions.	Consistently stayed aroused throughout the sessions. But she did sleep in three sessions less than 15% of the whole session and easily awakened.

(Table Continues)

Table 11, Continues

MATADOC outcomes	**P1**	**P2**	**P3**	**P4**
Findings of Section 2: Behavioral responses to music	Changes in facial gestures in response to form, rhythm, melody, timbre, pitch, and intensity.	Changes in facial gestures in response to timbre and melody.	Changes in facial gestures in response to melody and rhythm.	Changes in facial gestures only once when asked if she would like to read scores.
	Changes in eye contact in response to melody and form	Changes in eye contact in response to melody, rhythm, and form.	Changes in eye contact in response to rhythm and form.	Changes in eye contact in response to melody and timbre.
	Changes in physical movement in response to rhythm and melody	Changes in physical movement in response to timbre, rhythm, melody, and form.	Changes in physical movement in response to rhythm, dynamics, tempo, and form. Different physical responses. He would stay engaged for a few seconds after the music was over and eventually stop.	Changes in physical movement in response to melody, rhythm, tempo, and form.
	Changes in vocalization in response to pitch, melody, and form	Changes in vocalization in response to melody, rhythm, form, and dynamics.	Changes in vocalization in response to rhythm, melody, timbre, dynamics, and form. Often singing was mumbled and not finely connected with the music presented.	Changes in vocalization in response to melody and form.

(Table Continues)

Table 11, Continues

MATADOC outcomes	**P1**	**P2**	**P3**	**P4**
Findings of Section 2: Behavioral responses to music	Changes in arousal in response to melody and rhythm	Changes in arousal in response to melody.	Changes in arousal in response to form, melody, rhythm, dynamics, and timbre.	Changes in arousal in response to form, melody, and rhythm.
Findings of Section 3: Additional clinical information	Strengths: vocalization, attention to task, intentional behavior, and emotional response	Strengths: vocalization (showed a wide range of responses), attention to task, intentional behavior, emotional response, non-verbal communication, and choice making.	Strengths: vocalization with a wide range of responses, attention to task, intentional behavior, emotional response (several behaviors), non-verbal communication, and choice making.	Strengths: vocalization (sung all the words), non-verbal communication, choice-making, intentional behavior,
	Developing: non-verbal communication, choice-making, and motor skills.	Developing: Motor skills.	Developing: Motor skills.	Developing: attention to task, emotional response, motor skills.

Data explanation= Comparison of the MATADOC findings per participant, identifying baseline diagnostic outcome, observed behaviors at rest, and the results per section and items including noteworthy descriptive findings.

Table 12

Observed Findings Not Listed in the MATADOC but Elicited by the Protocol During Baseline Assessment

P1	**P2**	**P3**	**P4**
More positive behaviors appeared at rest after protocol. Arousal effect of the protocol.	More talking behaviors appeared at rest as post-observation	Musical behaviors at rest, but more present at post-observation, due to protocol stimulation and mood enhancement.	No changes in pre to post.
Recall of accurate melodies and words of part of songs on humming and singing, matching pitch and tempo with researcher	Recall melodies and familiar songs. Few words. Ability to read music not tracked in the MATADOC.	High scores in all areas except in vocalization due to a low number of words achieved.	High in all areas. Vocalization sang whole songs. Not tracked by MATADOC: score reading, identification of musical artists and instruments.
The hello song entrained to BR increased sleeping and worked better utilizing a familiar engaging song.	Active interaction when she was playing instruments.	Difficulties to analyze at rest. He initiated verbal interaction, observed at her wife walking and working in the house, and he answered to her talking to him.	Difficulties to analyze at rest. She initiated verbal interaction sometimes during pre and post.
Non-verbal. Few words, facial expressions and eye contact to communicate with the researcher.	Localizing sounds and level of verbalization were the items lower scored. Localization improved with cues.	High scores on every item. Impressive ability to improvise and enjoy playing and listening to instruments and music, without previous musical training.	A low emotional response with positive behaviors observed only in 2 out of 4 sessions
Purposeful movement of upper extremities when playing the drum with assistance	Most of the items rated as strengths and responsive to several aspects of music.	Changes in physical movement, vocalization and increased emotional response to music, and appearance of musical behaviors at rest could be signs of musicophilia.	Attention to task interrupted with sleeping and decreased arousal, but easy to keep awake.

(Table Continues)

Table 12, Continues

P1	P2	P3	P4
Emotional response to music through smiling and laughing. However, sometimes inappropriate.	High awareness level, therefore, impairments could be addressed to other areas such as memory, disorientation, confusion, and hearing loss.	As musicophilia has been associated with FTD, and he showed a low number of words in the singing task and rather mumbled sounds, plus stereotypical verbalizations during dialogue, this could support differential diagnosis of semantic dementia.	She did not show deficits in awareness; therefore, her cognitive deficits should be addressed probably to orientation to reality, short-term memory, executive function, mood disorders, and arousal.
Maintained attention during musical tasks and showed purposeful intentional meaningful behaviors like singing and playing the drum with assistance.	Although confused she showed appropriate orientation to reality and short-term memory when commenting about the songs presented.	No deficits in awareness and his cognitive deficits should be addressed to other areas most probably to memory, orientation, executive functioning, speech, and information processing.	Despite memory impairments, her ability to remember complete lyrics of songs, recognize musical instruments and some composers was unimpaired.
Improvement of functioning with sensory cues: auditory, visual, and tactile. Including section 1 scores.	Improvement of success during musical tasks with sensory cues.	Noteworthy improvement of mood after protocol, especially after active applications such as improvisation and music playing, but also with music listening.	Sleeping during musical tasks was not tracked by the 20% threshold in the arousal item of section 1.
Improvement of following commands embedded in music.	Improvement of mood with familiar music.	Increased responses to music not fully tracked by MATADOC. Probably, because what is characteristic is the high number and appearance of musical behaviors.	Her ability to read scores showed some impairment, but when the piece was easy (quarter notes, slow rhythm) she showed the ability to read well but skipped some parts.

(Table Continues)

Table 12, Continues

P1	P2	P3	P4
MATADOC responses could question the severe memory loss score of the CDR, and the lack of verbal abilities of the GDS.	Improved working memory evidenced in her ability to improvise music for periods over a minute.	P3 reached the ceiling of the scale, and besides vocalization, his deficits were not tracked.	She did not show agitation behaviors throughout the assessment.
The wording of section 3 ratings, developing not accurate with the population.	The wording of section 3 ratings, developing not accurate with the population.	The wording of section 3 ratings, developing not accurate with the population.	The wording of section 3 ratings, developing not accurate with the population.
MATADOC with this population should identify the need for assistance and include the sense of touch	MATADOC with this population should identify the need for assistance and include the sense of touch	MATADOC with this population should identify the need for assistance and include the sense of touch	MATADOC with this population should identify the need for assistance and include the sense of touch

Data explanation= The table summarizes the MATADOC findings and includes qualitative additional information observed during the assessment for each participant but not necessarily tracked by the MATADOC. The information is analyzed for each individual and suggestions for the adaptation of the MATADOC are provided.

Compared Caregiver's Reports

Table 13 in the next page provides a summary of the caregiver's reports about the intervention for each participant.

Table 13

Caregiver's Reports of the Intervention

P1	P2	P3	P4
Positive findings from two relatives, and one caregiver from the nursing home.	Not possible to obtain caregivers comments	The hired caregiver informed that sessions produced positive changes in mood, and that was more effective than recorded music, regarding connection, and social interaction.	Not possible to obtain caregivers comments
One neutral finding from a second caregiver at the facility		Private caregiver reported enhanced social participation and mood after sessions	
Positive facility caregiver mentioned increases in mood, arousal, and verbalizations		Spouse reported improved mood, connection, attention, and compliance with activities of daily living, such as getting dressed.	
The daughter of the participant mentioned changes in alertness and verbalizations. While the granddaughter, a 10-years-old child, said she looked better.		Both caregivers reported positive changes in mood (happier, joyful), increased awareness (connectivity, facial response, reaction to questions, listening to TV), increased social participation (integration), increased compliance (getting dressed, going for a walk, less negativity).	
The neutral caregiver said that P1 usually interacted through smiles and she observed no changes. She also added that it was not common for her to laugh.			

Summary of Suggestions to Fit the MATADOC for People with SSD

1. The outcome diagnosis of MCS and VS must be changed to fit the dementia population, while the name Higher-level appears appropriate. The wording of "developing" in section 3 is also inappropriate for people with dementia.

2. To fit the dementia population other areas should be assessed to control for relevant confounding variables such as hearing level, touch sense, and cognitive functions such as orientation to reality, executive function, attention, and memory (sensory, working, long-term).

3. In the auditory responses item, MATADOC for dementia could consider other responses besides turning head, such as pointing with the finger to the sound or let the person produce the sound for him or herself while identifying if the sound is present or not. Furthermore, it could be discussed if other responses such as vocalizations, laughing, moving away from the source, and changing her facial expression could categorize as a somehow valid response in the auditory responses item. On the other hand, it should disregard verbal identification of lateralization. The threshold can be also fine-tuned to identify differential responses above the defined threshold of 75% of responses.

4. Maintained ability to read music and words should be included in the MATADOC for dementia.

5. Increase the levels of responses in the "Vocalization" item to show that the person sang very few clear words, not always at the end of a phrase, and mumbled sounds but not with an attempt of singing words.

6. Include and identify types and levels of cues and prompts to increase success in tasks, such as visual, tactile, auditory, musical, and hand-over-hand assistance.

7. In the choice-making procedure, questions could refer to the session and assess short-term memory.

8. In the "verbal commands" item a score could be considered if the person follows commands embedded in the music.

9. Identify if there is a need for repetition for the person to recognize a song.

10. Verbal commands could be extended to two-step directions or other complex tasks in patients with moderate dementia.

11. Difficulties to observe at rest in patients with moderate and moderate-to-severe dementia, considering that participants initiated verbal interaction with the assessor. Consider flexibility in this section with more functional patients.

12. "Motor skills" item should be updated and further assessed to include for example coordination, gross, and fine motor control, such as finger dexterity.

13. In the "Emotional responses" item it could differentiate between consistent and inconsistent appropriate emotional behaviors, to track differences within this domain.

14. The number, type, strength, and frequency of behaviors, plus clinical history of increased responses to music could identify candidates for a diagnosis of "musicophilia".

15. It should include a simple hearing test previous assessment.

16. In the "Musical response" item it should include response to lyrics with no melody, and music reading.

17. Increase the space for narrative information and add a checkbox to see if patients were in a wheelchair.

18. Identify if patients respond positively to preferred music only, to unfamiliar music, or both.

CHAPTER V: DISCUSSION

The purpose of this chapter is to provide answers to the two research questions established in Chapter 1. One about the use of the MATADOC with people with advanced dementia. The other about the compared effects of the three auditory conditions live music therapy (LMT), recorded songs (RS) and auditory simulated presence therapy (ASPT) to increase signs of awareness and sense of self. These improvements were measured by the quantitative and qualitative outcomes of the MATADOC, the behavioral/thematic video analysis of the sessions, and the reports from the caregivers. Limitations of the study and recommendations for further research are reviewed.

What Were the MATADOC Findings with the Participants of the Study?

As a baseline assessment, both quantitative and qualitative data obtained with the MATADOC provided selective and relevant information about each participant's level of awareness. Most importantly, many of the items showed a direct relation with the level of deterioration, whereas at least two items showed a relation with the type of dementia, and one or two items showed a consistent high score on all the four participants.

Section 1 found consistency with the level of deterioration. In section 1, P1 was the only that showed inconsistent visual responses, and low response to verbal commands; in auditory response, both P1 and P2 both showed inconsistent head-turning to the sound and the other two consistent; P3 was the only one to consistently show awareness of musical stimuli, whereas P1 showed inconsistent responses within musical exchange, in the middle P2 and P4 showed a more fluctuant response between consistent and inconsistent; and regarding arousal, P4 showed lower baseline scores, followed by P1, whereas P2 and P3 showed no deficits in this area.

Section 2 showed a high response to music in all four participants, but the more severe patient showed increased response compared to the other three. This was expected since the scale was made to track changes typical for low awareness patients, such as increasing wakefulness. On the other hand, P4 the only participant with vascular dementia (VaD) due to stroke showed the lowest scores. In her case, the localization of damage, the motor impairment of one side, and the effects of the stroke on mood and arousal could have affected the behavioral responses to music too.

Section 3 found strengths and deficits in all areas, but a common highest score for the four participants in the *intentional behavior* item followed close by the *non-verbal communication* item. This is important to show that there was a maintained volition and non-verbal communication even in a non-verbal person with very severe cognitive decline due to mixed dementia with Alzheimer's Disease (AD).

The items that showed more relation with the type of dementia were *vocalization* and *emotional response*. In the *vocalization* item, P4 was the only one to achieve the highest score, and this was because her right stroke did not affect her speech or her long-term declarative musical memory. The three remaining participants represented each one a different level of cognitive deterioration, but they all achieved lower and similar scores. Noteworthy is that the moderate patient did not show a high level of verbalization, and the very severe non-verbal participant did not show a very low vocalization since she was able to retrieve words and melodies from familiar songs. The low scores of the moderate patient could eventually point to the differential diagnosis of semantic dementia, especially if it is considered the way he sang with no words and with no reference to the melody presented. Whereas, for the very severe participant a preserved brain musical network is consistent with the research in AD.

The *emotional response* item was a clear deficit for P4, and not as much as for the other three participants. In this case the brain damage appeared to affect her mood expressions, and this was observable in the emotional dysprosody of her speech. During baseline she only expressed her emotions once during verbal interaction and after reading scores. The other three participants were able to access the expression of emotions despite their level of deterioration.

The three other items of Section 3 showed consistency with the level of deterioration or brain damage. *Choice making* was only impaired for P1, which makes sense since she showed inconsistent to no response to verbal commands. P2 showed variability close to the highest score, and the other two showed consistent high scores, which could be the effect of hearing loss. *Motor skills* also showed lower scores for P1, while P2 showed variability close to the highest score, and the other two showed consistent high scores. *Attention to task* appeared as a strength for P2 and P3, and more impaired for P1 and P4.

The observations at rest also provided important information, as more behaviors were observed in the post observation in three out of the four participants when compared with the pre observation. This suggests that the protocol on itself increased signs of arousal, verbalizations, and/or positive mood behaviors. For P1 sleeping was far more common at the pre (four out of four) than at the post (one out of four). P2 showed talked more in the post observations (four out of four) than at the pre (two out of four), by talking with the assessor, with a doll, and with herself. She also slept once at the pre-observation. P3 showed musical behaviors at rest, and they were slightly more common in the post (three out of four) observational part than the pre (two out of four). He initiated verbal interaction with the assessor, with his wife, and his caregiver, or signs of positive mood in the post-observation at rest (four out of four).

Only one consideration was observed regarding the MATADOC protocol and it is related to the initial song. It was observed that an improvised song paired to breathing as it is indicated in the official protocol, increased sleeping behaviors during the song presentation with P1. The researcher found that a familiar song had an opposite effect and increased her arousal. Therefore, the researcher used a familiar song to open the session with P1 and maintained this approach every time the participants did not show wakefulness issues.

As a post-test, MATADOC did not track changes in the diagnostic outcome (Sum of Section 1) in any of the four participants, and most of the items scored within the baseline. Nevertheless, some individual items showed more variability and findings could be highlighted with each patient.

P1 showed changes in arousal during the observations at rest and in some individual items such as visual responses, verbal commands, vocalization, non-verbal communication, and choice-making. First, the three conditions showed wakefulness at the pre-observation, and since this was different from baseline, it supports the positive arousal effect of the three conditions. Then, it appeared that RS and ASPT plus a visit from loved ones, elicited a MATADOC post-observation at rest with more quantity and quality of behaviors (eyes tracking in several directions, initiation of verbal interaction, physical movements), suggesting increased arousal. Unexpectedly, sleeping was observed at the post-observation at rest after LMT, which is a significant change from baseline, since it never happened before. The Sum of section 1 was higher for RS and LMT compared to ASPT, with improvements in visual responses and verbal commands. Paradoxically, LMT showed slightly lower scores in *vocalization*, non-verbal communication, and choice-making, compared to RS and ASPT. All this data suggests that RS and LMT had a stronger effect increasing awareness and arousal levels compared to ASPT. But at the same time, the fact that P1 slept at the post-observation after LMT and showed lower scores in items of Section 3, suggests fatigue effects of one hour of active musical stimulation, which includes the active LMT condition plus the MATADOC protocol.

P2 showed no significant changes in the Sum of Section 1 after the three conditions compared to baseline and only variability in the *vocalization* item. Considering the high variability of responses during baseline and after the conditions, and her baseline speech characterization (tremors, bradylalia, dysarthria), her hearing impairments, and the neurologic deficits that were affecting her vocal musical expression.

P3 elicited no changes in the MATADOC during the post-test since he already appeared to surpass the ceiling of the MATADOC during the baseline. *Vocalization* was the only item where he scored low during baseline, and the despite the efforts of the LMT to increase those outcomes. The MATADOC was not sensitive enough to capture improvements in the number of words, improved pitch, and tempo.

P4 showed changes in the observation at rest, in the *awareness of musical stimuli, arousal,* Section 2, and in the *emotional response* item. Even though it was not possible to compare the LMT condition with the other two, due to the inability of the participant to maintain wakefulness during the LMT condition, she was awakened during the initial MATADOC hello song and was awake for the whole MATADOC procedure. This positive response is in line with the reports of patients with DOC that have shown increased arousal with this technique of playing a simple improvised song paired to breathing rate. Considering that the same technique caused the opposite response with P1, the researcher suggests that the official MATADOC hello song might work better with some patients with dementia that show wakefulness issues, in this case, a person with vascular dementia due to right stroke, but it can increase disengagement with a person with very severe cognitive decline due to AD.

After LMT she showed scores within baseline but decreased consistency in *musical awareness*, *arousal* items, and cero behaviors in *emotional response*. For the first time, she started the MATADOC with her eyes closed during the pre-observational period, but interestingly, she appeared fully awake during the post-observational period. Since she woke up during the initial hello song, she obtained higher scores in Section 2, accounting for increased arousal as a response to melody and form.

After ASPT she talked to the assessor on the post-observation but not on the pre and showed full arousal but inconsistent awareness to musical stimuli, just as the baseline. But after RS she initiated verbal interaction in both pre and post observations at rest; she achieved a maximum score of 10 in the Sum of Section 1 by improving in arousal and awareness to musical stimuli; and increased her scores to an unseen maximum in the emotional response item. This was the first time she showed several emotional behaviors during the protocol. It could be inferred that positive mood changes could have had a positive effect on enhancing her cognitive function and increasing her response in musical awareness and arousal items.

To sum up, MATADOC as a baseline assessment was able to identify strengths, deficits, and levels of awareness in all the four participants, and differential responses of the items regarding the level of deterioration and type of dementia. In general, a higher level of deterioration identified by the Global Deterioration Scale (GDS) resulted in more deficits found in the MATADOC to a point where the participant P3 with moderate dementia showed an almost perfect score on all items except for the *vocalization* item. Section 1 and three items of the Section 3: *attention to task, motor skills, and choice-making* showed consistency with the level of deterioration. Section 2 identified high responses to music in all 4 participants, but higher in the very severe one. Two items of Section 3 *intentional behavior* and *non-verbal communication* had high scores in the four participants. *Vocalization* and *emotional response* appeared possibly related to type of dementia or localization of brain damage. Additionally, the comparison of the periods at rest before and after the protocol showed that the protocol on itself increased the appearance of behaviors showing awareness in three out of four participants. The hello song paired to breathing rate increased sleeping in P1 and it was changed to a familiar song. These outcomes support a musical environment to improve the response of people with moderate and severe dementia.

As a post-test MATADOC identified some changes for P1, P2, and P4, and it did not track any changes for the moderate participant P3 after each condition. Neither of these conditions elicited changes in the diagnostic outcome. Although within baseline scores, P1 showed better Sum of Section 1 after LMT and RS compared to ASPT, whereas LMT plus MATADOC protocol could have produced fatigue based on sleeping at post-observation at rest. P2 showed a similar response to the three conditions and only changes in the *vocalization* item that could not be fully addressed to the effects of the conditions. However, the cough attack incident during RS while using headphones may have decreased her *emotional response* to zero. P4 showed better results to RS than ASPT, and lower score after LMT due to low wakefulness state. She also showed a higher arousal with the protocolized MATADOC hello song paired to breathing rate, and together with the response of P1 suggests that this technique could be used with some patients with dementia with wakefulness issues.

Considering all the Collected Data Including the MATADOC Scores, Video Behavioral/Thematic Analysis, and Caregiver's Reports, Which Condition Had a Better Effect Increasing Levels of Awareness and Signs of an Enhanced Sense of Self?

For the most part, all the conditions had a positive effect on social interaction with the assessor, active listening, signs of positive mood, verbal interaction, and pragmatics of communication, but the music conditions showed increased response in either cognitive, physical, or emotional areas for all 4 participants compared to ASPT. Three out of four participants showed increased response with LMT and one with RS.

P1 and P3 benefitted from both music conditions but showed increased access to language through LMT, therefore benefitting more from it than the other two conditions. Both participants had positive reports from caregivers, and positive behavioral/thematic findings after the music conditions regarding increased positive mood, physical movement, and access to language. Additionally, P1 also showed higher MATADOC scores within baseline compared to ASPT. During RS both participants showed wordless singing (P1 hummed, P3 mumbled), positive mood behaviors, and increased movement to music, but only LMT showed also maintained declarative musical memory through singing well-known songs. In the case of P1, this was achieved through validation, adapting tempo and the form of the song to accommodate her verbalizations, and leaving blank spaces for her to fill in. She was also able to increase her comprehensive language during LMT and she followed verbal commands embedded in the music such as "clap your hands" or "sing with me".

In the case of P3, he could only recall few words of songs on his own, and during RS he sung and appeared animated by the sound of music but not connected to the specific song neither on pitch nor rhythm. Therefore, his LMT approach to access language was successful through reading lyrics, singing with guitar and a capella, and being assisted by the therapist by pointing with him in the sheet while reading and singing. Interestingly, during MATADOC he was still able to recall some words of the practiced songs, but MATADOC was not sensitive enough to capture these improvements in the number of words. On the other hand, he verbally referred to the session during MATADOC after RS, suggesting maintained working memory. Her caregivers reported positive effects of the whole intervention that remained after the sessions were over, such as increased awareness, mood, compliance with ADLs, and social participation. He also successfully improvised with the keyboard during MATADOC and had no musical training. Overall, he appeared as an ideal candidate for music therapy and music treatments due to behaviors supporting musicophilia.

P2 benefitted slightly more from LMT but closely followed by ASPT, while during RS she had the cough attack incident were music had to be discontinued and therefore had a negative emotional effect at the end of the procedure. Both ASPT and LMT showed same MATADOC scores and access to autobiographical memory, but LMT showed more connected answers to verbal questions presented, more spontaneous autobiographic memories reminisced, consistent musical interaction reflecting maintained cognitive resources, lyrics singing, and good access to long-term memory (lexical and semantic) through reading and singing. The fact that in both conditions she showed lower scores in the *Vocalization* item in the MATADOC compared to baseline and even with RS, and based on verbal statements showing a low auditory understanding of words, it is highly possible that hearing disorders affected the comprehension of questions and processing of music.

P4 benefitted more from RS than ASPT, and LMT was not comparable since she was sleeping during the MT condition. Both RS and RM had very similar responses over social interaction, long-term memory (lexical, autobiographical, semantic), and short-term through staying on task during the conversation. But LMT produced stronger increases in mood and a higher score in the MATADOC. Elevated mood behaviors were triggered through dialogue in a follow-up of song listening and persisted enough to show increases in MATADOC scores. These elevated mood responses were unique and unseen during the baseline and the other conditions. However, the similarity of scores with the first session of baseline, and the fact that in that session she showed one smile (the only smile in the baseline), suggests that increasing mood of P4 improved awareness levels, and overall cognitive function, observable in responses to musical stimuli. On the other hand, LMT showed moderate effects increasing arousal levels and awareness of musical stimuli. Since she woke up during the hello song procedure from the MATADOC, it was most probable that the sum of the LMT condition and the song procedure paired to breathing rate together woke up the participant. Therefore, the researcher suggests that this technique should be included with patients with low states of alertness like P4 during music therapy interventions.

Conclusions

The present study case with four participants with moderately severe, severe, and very severe cognitive decline due to dementia found that MATADOC might be a valid way to assess awareness. Most of the items showed consistency with the level of deterioration, including the section 1 with the diagnostic outcome, but at least two items of *vocalization* and *emotional responses* showed more consistency with the type of dementia, condition of vocal health, or localization of brain damage. Whereas the two items of *intentional behavior* and *non-verbal communication* showed higher scores across the four participants, indicating that volition and non-verbal communication might be maintained despite very severe cognitive decline. Despite these positive findings, the MATADOC assessment was limited as it did not track cognitive, sensory, and declining factors appropriate for the dementia population. A list of eighteen points was elaborated to either change, adapt, or include in an updated version of MATADOC for dementia.

Regarding the comparison of treatments, the two music conditions together showed better responses in 100% of participants compared to ASPT regarding cognitive and/or emotional areas enhancing the sense of self of the participants. But the active approach in LMT had better effects in 3 out of 4 participants, while RS was highly effective in 1 participant. At the same time, RS showed 1 negative effect due to the risk of using headphones in a person with a chronic cough. Whereas ASPT showed positive but limited effects with the 4 participants. Overall, these findings were consistent with the reviewed literature in terms of increased response to music in people with advanced dementia, with good outcomes for both conditions but with increased outcomes for live music therapy, and in terms of the existence of risks of harm of listening to music with headphones.

Limitations

The study had a small sample size of four participants; therefore, findings should be considered with caution and should not be generalized to the overall dementia population. The MATADOC which was at the center of this study is not a valid assessment tool for people with dementia, and its results should also be addressed with caution. Nevertheless, the idea of the study was to explore the use of MATADOC with the dementia population and identify areas of need and possible adaptations. The lack of caregivers reports for two out of four participants was also another limitation to access either positive or negative findings in-between sessions. Lack of proper hearing devices to amplify sounds for one of the participants could have affected the adequate processing of music and sound. Medication and sleeping schedule were not considered and could have affected the arousal levels in two of the four participants.

Recommendations for Future Research

The first recommendation is to replicate this study with a larger sample to corroborate or not the current findings of the study. These findings are three: that the deterioration level is associated with most of the items of the MATADOC, including the section 1 with the diagnostic outcome, that some other items are more associated to the type of dementia, and that some few others are consistently high even in the very severe stage of cognitive decline. For this matter it would be important to compare the MATADOC with more updated global staging scales for dementia since the GDS has statistical limitations, and the CDR is too broad to differentiate the severe from the very severe stage.

A second recommendation would be to elaborate a MATADOC scale for the population with dementia that could consider cognitive, sensory, and declining factors that are relevant for the population. This, to find confounding variables and establish a more appropriate assessment to cover the specific diagnosis of dementia. A list of 18 suggestions was elaborated by the researcher and it was included at the end of the Chapter 4 Results. This study acknowledges the differences between DOC and the SSD in terms of diagnosis, etiology, auditory processing, musical processing, assessment, and treatment, and encourages the need to develop differential assessment instruments, as well as standardized treatment and evaluation plans, that could consider dementia subtypes and changes throughout the disease.

A third recommendation is to pursue a systematic review for the identification of risks of harm of music listening treatments and to elaborate trainings to educate non-music therapy staff in the delivery of music listening with patients with dementia. Through the literature review and the results of the study it was found that there are positive effects of listening to recorded music, but at the same time there are risks of physical and psychological harm. However, the research in this area is scarce and there is a need to fill this gap with high-quality research. The identified risks of harm suggest that music listening treatments should be delivered with caution, with the presence of a responsible trained caregiver, and patients should not be left alone during music listening periods. The best situation would be that music therapists and hopefully through associations such as the American Music Therapy Association (AMTA), could elaborate guidelines and programs for training to certify caregivers in the delivery of music listening treatments. Training with these characteristics should include at least awareness of risks of harm, mitigation of risks, effects of music in people with dementia, auditory and musical processing in people with dementia, and ethical considerations.

A fourth recommendation would be to further analyze the relation between frontotemporal dementia and musicophilia. Based on the reviewed literature, patients with frontotemporal dementia can show changes in hedonic responses, such as increased craving and liking of music. The fact that P3 in this study showed signs of musicophilia through increased quantity and quality of musical behaviors, that his neurologist was unsure of his diagnosis of AD and requested new neuroimages, and that when exposed to music he mumbled melodies without words, might show signs of a differential diagnosis of semantic dementia, a variant of frontotemporal dementia. The research in this area is scarce, and due to the low prevalence of the condition, at this point it would be important to have more case studies that could show this relation.

A fifth and last recommendation is to elaborate longitudinal research for the prevention or early intervention of dementia considering the recommendations of the Agency for Healthcare

Research Quality (Kane et al., 2017). Music therapy is a multimodal approach that can increase adherence to treatment, improve mood, and provide cognitive training and/or physical activity. Plus, recent studies have found increased functional connectivity through listening treatments in early AD. Therefore, music therapy might provide treatments that could be effective and in line with the most updated research and recommendations. Furthermore, it would be necessary that a major organization such as the AMTA would define the best criteria of measures and designs to develop such studies, therefore, defining scales, variables, and a plan of research where the results could be effectively pooled together to identify effects of treatment in the medium and long-term.

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APPENDIX A: LETTER OF PERMISSION FORM

Legal Permission for Participation in Research

Title: Use of the Music therapy Assessment Tool for Awareness in Disorders of Consciousness [MATADOC], and comparison of recorded messages, recorded songs, and live music therapy to increase measures of awareness in patients with severe stage of dementia, an exploratory study.

Introduction

The purpose of this form is to provide you (as the legal representative of a prospective research study participant) with information that may affect your decision as to whether or not to let your relative participate in this research study. The person performing the research will describe the study to you and answer all your questions. Read the information below and ask any questions you might have before deciding whether or not to give your permission. If you decide to let your relative be involved in this study, this form will be used to record your permission.

Purpose of the Study

The purpose of this study is twofold:

1. To explore the use of a validated music therapy assessment tool called Music Therapy Assessment Tool for Awareness in Disorders of Consciousness [MATADOC] with patients with severe stage of dementia. This assessment tool was originally developed for comatose patients with Disorders of Consciousness (such as people in vegetative states), but we want to know if it is also effective to measure awareness in people with severe stage of dementia.
2. To compare the effects of three different auditory conditions on increasing measures of awareness. These auditory stimuli will be: familiar recorded songs, recorded spoken messages by relatives, and live music therapy.

The main goal of this study is to increase levels of awareness in patients with severe stage of dementia.

What is my relative going to be asked to do?

If you allow your relative to participate in this study, they will be asked to:

* Listen to familiar songs sung by the researcher through live music, eventually these songs will be paired with a gentle touch of hands.
* Listen to recorded familiar songs with headphones at a comfortable level (55 dB).
* Listen to verbal messages recorded by relatives with headphones at a comfortable level (55 dB).
* Listen to single sounds played separately on each ear to assess hearing.
* Visually track a musical instrument moved in their visual field.
* Follow verbal commands such as "touch the guitar" or "look at the drum".
* Sing, hum, or play the guitar or a drum with the help of the researcher if possible.
* Answer questions about music preference, memory, problem-solving, hobbies, if possible.

This study will take 5 weeks to be implemented.

The first two weeks you and/or other relatives that know well the participant will be interviewed to collect information about his/her music preference, and relevant information regarding the current function of your relative, within the areas of memory, orientation, judgment and problem solving, community affairs, hobbies, and personal care. During that period, you will also be asked to record a message of 30 minutes telling some shared important moments that your relative might remember well.

The third week the level of awareness of your relative will be assessed with the Music therapy Assessment Tool for Awareness in Disorders of Consciousness [MATADOC], on 4 sessions of 30 minutes each. This assessment consists of listening to songs (live or recorded songs), simple sounds (tone bells), tracking visual stimuli (follow a drum with their eyes), and asking him/her to respond to verbal commands.

Finally, either on the fourth or fifth week, during three consecutive days, your relative will be presented with 30 minutes of: recorded familiar songs, recorded message by loved ones, and live songs presented by the researcher, and immediately after will be re-assessed with the MATADOC for another 30 minutes, to track any changes in his/her level of awareness. Each session will last approximately 1 hour (30 minutes of stimuli and 30 minutes of assessment), and each day different stimuli will be presented to him/her.

This study will involve 1 to 4 participants.

This is a research study and, therefore, not intended to provide a medical or therapeutic diagnosis or treatment. The intervention provided in the course of this study is not necessarily equivalent to the standard method of prevention, diagnosis, or treatment of a health condition.

What are the risks involved in this study?

Possible risks associated with this study are risks of psychological/emotional distress from music that elicits bad memories. For this reason, a questionnaire with appropriate preferred music will be given for the relatives to complete, then the researcher will select the music that has a more positive message. In case the client shows signs of distress (face grimacing, moaning, agitation) the music or the recorded messages will be immediately stopped. The likelihood for this to occur is minimal. Other risks are related to a breach of confidentiality that may occur; however, these risks are minimized by keeping all the data locked in a password-protected computer and a locked file cabinet and then destroyed.

What are the possible benefits of this study?

The possible benefits of participation are the possibility for your relative to having increased arousal for communication. The MATADOC assessments will also provide important information for caregivers about the participant's current sensory level of awareness, especially regarding auditory and visual responses. For society, the benefits will include the possibility to suggest an assessment and treatment increase awareness for patients with Severe Stage of Dementia.

Does my relative have to participate?

No, your relative's participation in this study is voluntary. Your relative or you may decline to participate or to withdraw from participation at any time. Withdrawal or refusing to participate will not affect their relationship with Sugar Creek Alzheimer's Special Care Center or Illinois State University in any way. You can agree to allow your relative to be in the study now and change your mind later without any penalty.

Will there be any compensation?

Neither you nor your relative will receive any type of payment participating in this study.

How will your relative's privacy and confidentiality be protected if s/he participates in this research study?

Your relative's privacy and the confidentiality of his/her data will be protected storing it in a password-protected computer within a password-protected folder, where only the researcher has access.

When required by law or university policy, identifying information (including your signed consent form) may be seen or copied by authorized individuals.

If you choose to participate in this study, your relative will be video recorded. Any video recordings will be stored securely and only the research team will have access to the recordings. Recordings will be kept only for the duration of the study (no more than 3 months after the implementation of the study) and then erased.

Who to contact with questions about the study?

Prior, during or after your participation you can contact the researcher Nicolas Espinoza at (309) 585-7069 or send an email to naespi1@ilstu.edu for any questions or if you feel that you have been harmed. This study has been reviewed and approved by The University Institutional Review Board and the study number is IRB-2019-41

Who to contact with questions concerning your rights as a research participant?

For questions about your rights or any dissatisfaction with any part of this study, you can contact, anonymously if you wish, the Office of Research Ethics and Compliance (REC) at 309-438-5527 or IRB@ilstu.edu

Signature

You are deciding to allow your relative to participate in this study. Your signature below indicates that you have decided to allow him/her to participate in the study. If you later decide that you wish to withdraw your permission for your relative to participate in the study you may discontinue his or her participation at any time. You will be given a copy of this document.

____
Printed Name of Relative

___________________________________ __________________
Signature of Legally Authorized Representative Date

___________________________________ __________________
Signature of Investigator Date

APPENDIX B: MATADOC BASELINE REPORT, NARRATIVE OF CONDITIONS, AND MATADOC POST-TEST REPORT FOR P1

MATADOC Baseline Report

Observed Responses at Rest

During the pre and post, behavioral observation periods of each assessment session P1 demonstrated several positive behaviors during periods of no stimulation. It was common to see movements of the trunk (straightening, leaning forward/back), head (small movements, rotation to both sides, looking down), hands (finger movements, touching face or chin), and feet lifting. Fine motor movements were observed when she grasped her blanket or adjusted her shirt with right or left hand. A few times she vocalized word salad phrases and laughed. It was also very common to see her eyes closing to sleep followed by falling off the trunk and head, which corroborated her sleeping state. However, this was more common for the pre-observational part (4 out of 4), than for the post-observational (1 out of 4), which most probably was due to the effect of the stimulation of the protocol. The only time she slept during the post-observational part was in the third session when recorded music was used to assess her during the protocol. In general, more movements were observed during the post-observational period than in the pre-observational period, except for the third session. In the first, second, and fourth sessions, rhythmic behaviors were observed such as head nodding, tapping of the feet, and tapping of hand, and were due most probably as a rhythmic consequence of the protocol. During the post-observational part of the fourth session, a more complex movement was observed: quilt folding, which included movements of the head, trunk movements, arms flexion/extension, hand grasping, and hand-eye coordination.

Session 1

Pre-observational	Post-observational
Small trunk movements	Small trunk movements and straightening
Small head movements	Head rotation to L and R
Small hand movements	Head looking down
Small movements of feet	Blowing
Eyes closing	Right hand grasping blanket
Sleeping with head and trunk falling	Head nodding
	Trunk pushing against the chair

Session 2

Pre-observational	Post-observational
Hands held together	Hands held together
Small finger movement	Hand tapping L over R
Eyes closing	Small finger movements
Sleeping with head and trunk falling	Head rotation to L and R
	Trunk forward and back
	L hand reaching to her back to fix her shirt
	Laugh
	Answers to door knocking by looking and mumbling something like "come in"

Session 3

Pre-observational	Post-observational
Small hand movement	Head movement
Head movements	Small finger movement
Right hand grasping blanket to shoulder	Trunk straightening
Head rotation to L and R	Eyes closing
Vocalizes a word like "pick"	Eyes opening
Laughs	Sleeping with trunk and head falling
Small finger movements	
Eyes closing	
Sleeping with head and trunk falling	

Session 4

Pre-observational	Post-observational
Small hand movements	Feet tapping (L, R, and both)
Head rotation to the L and C	Quilt folding (includes movement of the head, trunk movement, arms flexion and extension, hand grasping, and hand-eye coordination)
Right foot lifting	R leg movement (lift and extend)
Eyes closing	Vocalization (mumbles something to herself)

Eyes opening	Body adjustment (arms pushing up the body with trunk forward)
Sleeping with head and trunk falling	
Trunk straightening	

MATADOC Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Musical instruments like a drum and a guitar, and pictures of well-known artists for her (Dean Martin, Dolly Parton, Kenny Rogers) were presented as stimuli and at a distance of approximately 1 foot. In 2 sessions she consistently followed the stimuli over the 4 quadrants (Left, Right, Up, and Down). In 2 other sessions, she was more inconsistent and stopped tracking in the middle of the task, as she was forgetting to track the stimuli. However, verbal prompts (saying her name, or commanding her to look, or keep looking) were most of the time useful to help her getting on task again. In general, pictures of artists were more effective to engage her attention towards the visual stimuli than instruments.

Responses to auditory stimuli. Guitar playing and singing were presented in P1 midline. The guitar playing was played in direct response to P1´s breathing patterns to open the protocol and awake her. Improvised music was not effective in awaking her, even using a gentle touch of hands and arms, but, when paired to a known melody she responded moving her trunk, singing, humming and few times opened her eyes for a short period. Simple commands like calling her name or prompting her to open her eyes were much more effective to awake her. However, in session 4 a well-known song "Daisy Bell" was used instead, she did not track to the midline until towards the end of the song where she opened her eyes, looked to the front, and smiled. After this, she continued engaged and sung some words of the song.

During the specific auditory tracking part of the protocol, auditory stimuli including dissonant combinations of pitches on chime bars (A3, D#6), and percussive spoons, were presented on P1's right and left side close to her ear. She was awake in every session and responded verbally if prompted, however, she inconsistently showed awareness of the stimuli. She turned her head a few times towards the stimuli, but she responded in some other ways: face grimacing, moving away of the stimuli, laughing, saying interjections of pain, and sighing. These responses were more consistent with the high loud pitch than with the low pitch. Percussive spoons did not elicit any specific response.

Awareness of the musical stimuli. P1 showed inconsistent interactive responses within musical exchange throughout the four sessions. Behaviors that showed signs of awareness were that she matched the pitch and tempo of the assessor when humming, singing, or clapping, and also that she sang specific words corresponding to the lyrics of the songs presented. Additionally, eye contact during the first and second session was maintained consistently, but the next two sessions it was more inconsistent and sometimes lost through the task, however, changes in music like introducing silences were effective to engage her again. Songs played a capella and paired with tactile stimulation (waving her arm to the music, tapping her hand) were effective to increase the duration of her eye contact. Other common responses were tapping her foot and moving her head to the music. Many times she did not respond when the music was over, and some others she laughed or mumbled words at the end of the song with a consistent delay of 4 seconds.

Response to verbal commands. P1 responded inconsistently to verbal commands like "touch the drum". Many times, she kept looking to the assessor after the command, other times she answered verbally by saying "yes", "hm", "I don´t know", she repeated a word from the command, or looked away. However, in most of the sessions, she moved her hand after the command was repeated, and if tactile priming and visual cues were added, she moved her hand more but stopped before reaching the drum. In two sessions hand-over-hand assistance was provided to raise her wrist and she completed the movement reaching for the drum on her own. Only in two sessions she reached and touched the drum on her own after providing tactile priming with hand-over-hand assistance.

Arousal. P1 stayed aroused throughout or more than 90% of sessions 1, 2, and 4. In session 1 she slept only during the hello song. In session 2 she fell asleep during hello song, auditory tracking, and visual tracking, but the assessor kept her engaged by calling her name, changing the stimuli, and providing tactile stimulation. In session 3 where she fell asleep for about 20% of the session. In session 4 slept during the presentation of a soft song which was discontinued. She woke up with the music during the fourth session using "Daisy bell" to open the protocol, but improvised music was not as effective to this purpose than using a familiar melody. Recorded music was less effective to keep her engaged as she slept during half of the song presentation.

Diagnostic outcome. P1's scores were congruent with the presentation of someone in Minimal Conscious State (MCS). In the 'Essential Categories Principle Subscale' over the four MATADOC assessment sessions in the response categories (visual, auditory, awareness of musical stimuli, verbal commands, and arousal) P1's total scores were: Session one: 7 (MCS), Session two: 5 (MCS), Session three: 6 (MCS), Session four: 5 (MCS).

MATADOC Section 2: Behavioral Responses to Music

P1 showed several responses to music. Changes in facial gestures like smiling were observed consistently in response to familiar songs, and face grimacing was observed twice in response to a high loud pitch played with the tone bell, which can be a response to pitch + intensity. Most of the time eye contact was initiated during song presentation and increased in response to changes in the music like the introduction of silences or when paired with tactile stimulation, however, eye contact was sometimes disengaged through a song, especially after the chorus or second verse, which suggests a response to form. Physical movements like foot tapping and head movement appeared with more upbeat music and suggest a response to the rhythm in familiar songs. Consistent changes in vocalization were observed such as humming (very frequent and in pitch) and singing with accurate words and mumbling, all in response to familiar melodies. Changes in arousal were observed when she woke up with a familiar rhythmic song (live and recorded), however with the recorded one she fell asleep again. Observed responses to form were laughing, commenting words ("that’s good") after a song was over, and singing the last word at the end of a phrase. Most music presented was using guitar and voice, while recorded music elicited partial responses, which included humming, smiling, moving to music, waking up, and sleeping.

MATADOC Section 3: Clinical Information to Inform Goal Setting and Clinical Care

Vocalization, attention to task, intentional behavior, and emotional responses were rated as strengths, for showing having a high level of response. While other responses were rated lower as developing areas and included non-verbal communication, choice-making, and motor skills. Vocalization responses consistently included humming, and frequently included filling-in the blank the last word of phrase that acted as cue, and even, in some songs like "You are my sunshine" she sang most of the words, in other songs like "I´ve been working on the railroad" she sang some words, and others were mumbled. Noteworthy was her ability to maintain and remember the melodies and some lyrics of familiar songs. Using recorded music only humming was observed. Attention to task was rated high as she participated for the whole session, although needing prompts or changes in the stimuli to stay awake. Intentional response with goals achieved was observed when humming and singing songs when playing the drum with the mallet needing prompts to start doing it, responding to a prompted high five and reaching to grab the drum although the task was to track it. Emotional responses appeared on many occasions and included smiling and laughing to presented songs. However, laughing appeared on occasions when it was not appropriate, for example as an answer to a follow-up question, or as a response to a verbal command. Only once in the first session, she commented "that's good" after "Take me home country roads" was played. Non-verbal communication showed inconsistent spontaneous use of social communication gestures without prompts. Although her eye contact was good for the most part, some other times needed prompts to re-engage as she started looking at her nails or looked away. She gave her hand to shake it with verbal prompts and visual cues. Choice-making appeared impaired and did not communicate a choice when asked what instrument she preferred. However, she was able to look at both objects presented in a sequence and simultaneously. Motor skills appeared to need prompts or physical facilitation during specific tasks like playing the drum or clapping her hands, but not in session 4 were she reached for the drum on her own with both hands, showing purposeful independent movement.

Relations Between the MATADOC, the GDS, and the CDR

P1 was assessed using the Clinical Dementia Rating Scale (CDR) by the Student Music Therapist. During the interview for the CDR, she appeared not to process the questions. She answered with phrases like "oh dear", "I don't know", or used word salad phrases, but for the most part did not answer to questions. She obtained a final score of 3 in the Global Dementia Scale, which accounts for a severe level of dementia. She scored severe in most of the items, therefore showing severe memory loss, oriented only to person, unable to make judgments or problem solving, with no significant function at home, requiring total help with personal care, and frequent incontinency. She scored moderate only in community affairs, as she appeared well enough to be taken to functions outside a family home, with no pretense of independent function.

Using the Global Deterioration Scale, she scored a 7, meaning "Very severe cognitive decline" or severe dementia. This item is described as following: "All verbal abilities are lost over the course of this stage. Frequently there is no speech at all -only unintelligible utterances and rare emergence of seemingly forgotten words and phrases. Incontinent of urine requires assistance toileting and feeding. Basic psychomotor skills, e.g., ability to walk, are lost with the progression of this stage. The brain appears to no longer be able to tell the body what to do. Generalized rigidity and developmental neurologic reflexes are frequently present.". The responses obtained during the MATADOC could question the severe memory loss score of the CDR, and the lack of verbal abilities of the GDS as lyrics from well-known songs are moderately preserved. MATADOC also showed that a musical environment can improve short-term memory skills like following commands embedded within the music with commands like "sing with me".

Results and Recommendations of the MATADOC Assessment

MATADOC outcomes indicate that P1 is responding at a Minimal Conscious State (MCS) level. She demonstrated awareness of herself and her environment, but it was inconsistent throughout the four sessions.

Comparing the pre-observational period with the post-observational period is highly probable that the protocol on itself had an overall arousal effect on P1, as sleeping behaviors were most commonly observed before the protocol, and not usually after.

During the assessment she showed many strengths within a musical environment such as retrieving words and melodies from well-known songs through humming and singing, matching the same pitch of the assessor when singing, communicating non-verbally through eye contact and face expressions with the music therapist, connecting the body towards a purpose like playing a simple instrument with upper extremities, responding with emotions to music through smiling and laughing, maintaining attention to task, and working with an environment to produce intentional meaningful behavior like singing. It is noteworthy that her responses could be increasingly successful if well-known songs are used and receiving assistance such as visual cues (modeling), tactile stimulation, and hand-over-hand assistance. For example, her response to verbal commands was much more appropriate when the command was embedded in music. The command "sing with me" in the middle of a song was followed consistently engaging her in singing. The command "clap your hands" and "clap faster" was followed appropriately after training it with visual, musical, and tactile cues during the second session.

In conclusion, as part of her hospice care music therapy would be recommended to work on maintaining cognitive, spiritual, emotional, physical, and social areas, and including the family to further connect with her. This could be highly beneficial for her quality of life and her loved ones.

Stimuli 1 - ASPT

The audio of participant P1 lasted 14 minutes and 40 seconds and consisted of her two daughters telling different stories such as an important pet, trips, family picnics, surviving from a tornado, how P1 met with her husband, between others. The whole listening procedure lasted 23 minutes, which included listening to the recording and following-up with the investigator before, in-between, and after the audio listening. The audio was presented through headphones, and during the listening task P1 appeared to be actively listening, for the most part, this based on the fact that she was in silence and responded interactively with different behaviors such as laughing, smiling, commenting word salad phrases, and also clear words and phrases like "yes", "that was what I was thinking", "yeah it was", and "oh dear". Laughing responses appeared when the speakers were laughing too, however, P1 did not laugh every time their daughters were laughing. She also looked away during some moments of the procedure, where she appeared to lose contact with the task. She fell asleep twice, which triggered the investigator to stop the recording and start a conversation with her to refresh her attention and check for her active responses to what she had just heard. During these interactions, the investigator asked her questions about who the speakers were or asked about the specific stories that were shared, as open-ended questions, yes-no questions, and giving options for her to choose the answer. P1 responded with "yes", "no", "hmm", and word salad phrases, using inflections of the voice as if she was maintaining a conversation. The pragmatics of the dialogue situation, for the most part, was appropriate: following turns to answer and engaging in eye contact with the investigator. Nonetheless, P1 did not respond in any way that could show an understanding of the questions. The only relevant answer she did was that she opened her eyes more and said "yes" twice and with increased strength when asked about the tornado. Another relevant answer was that she consistently said "yes" when asked if the stories were happy memories, the researcher followed-up and asked if those were sad memories, and she said "no", the researcher asked again "happy?" and she said "yes".

MATADOC After ASPT Plus Visit from Loved Ones.

Just when the pre-observation part had started P1 received visits from her daughter, her son-in-law and her granddaughter. The procedure had to be interrupted and continued after the visit. Therefore, the stimuli included also a 15-minute visit from loved ones.

Baseline responses

Pre-observational	Post-observational

Left hand under chin	Left foot down the chair, then both feet down, and tries to get out of the chair
Looking down	Trunk forward/back
Head rotation to R and L	Arms holding the chair and pushing up the body
Small trunk movements	R foot movement
Adjusting shirt and pants includes bilateral flexion/extension of upper extremities, finger dexterity, and hand-eye coordination	Left hand touching/scratching head, touching chin/neck, adjusting the shirt
	Smiling
	R hand movement looking for something on the chair
	Left hand crossing midline
	Head movement (Left, center, right)
	Eyes tracking in all directions constantly
	Laugh
	Talking alone ("oh dear", "oh I can´t")
	Initiates verbal interaction with the researcher saying something like "what are you gonna do [mumbles]" reinforcing the question with an appropriate hand gesture
	Feet tapping constantly

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Inconsistently tracked the visual stimuli. As usual, she locked-in well with the stimuli, and after a few seconds, she forgot to keep tracking with her eyes, needing verbal prompts to stay on task, which worked. She attempted once to grab the drum.

Responses to auditory stimuli. Inconsistently tracked to auditory stimuli, as usual, most of the time she did not respond to the tone bells played on the sides, although turned once with the high tone bell, and said "hm" after the low tone bell, both on her right side, and moved away her head when both tone bells were played on her left. She did not respond to percussive spoons. She tracked to the midline when music was presented in front of her.

Awareness of musical stimuli. Showed inconsistent interactive response within musical exchange.

Responses to verbal commands. No response to verbal commands. The command given was "touch the drum", in 2 out of 7 she moved her hand once but not lifted, and the other one rubbed her face with her hand. However, these responses were observed at rest, therefore not reaching significance.

Arousal. Stayed aroused throughout the session, or for more than 90% of the protocol, only slept for 10 seconds towards the end of visual stimuli.

Diagnostic Outcome. Score 5, Minimal Conscious State

Section 2: Behavioral Responses to Music

Same changes observed previously. Changes in facial gesture through smiles and laughs at the end of songs, which accounts for a response to form, however, she did not respond every time a song ended. Eye contact increased with the presentation of songs but sometimes was lost during the task. She hummed and completed cued words of songs which were a response to melody and form. Both soft and loud music engaged her.

Section 3: Clinical Information to Inform Goal Setting and Clinical Care

Same scores than baseline. Strengths in vocalization, attention to task, intentional behavior, and emotional response. Developing areas in non-verbal communication, choice-making, and motor skills.

Stimuli 2 - RS

The procedure lasted approximately 35 minutes and consisted of listening to eight whole songs and then follow up with the investigator, who asked questions to her about the songs. Additionally, four more 1-minute excerpts of songs were presented without follow-up. The songs presented included "Jingle Bells" and "Let me Call you Sweetheart" by Bing Crosby, the opening of the soap opera "The Young and the Restless", "I´ve Been Working on The Railroad" and

"She´ll Be Coming Round the Mountain" by Pete Seeger, "Daisy Bell (Bicycle Built for Two)" by Nat King Cole, "Rock Around The Clock" by Bill Haley and the Comets, "Jolene" by Dolly Parton, "You Are My Sunshine" by Johnny Cash, "Grandma Got Run over by a reindeer" by Elmo and Patsy, "Down by the riverside" by Louis Armstrong, and a choral version of the hymn "Rock of Ages". All the songs were chosen with the help of the Questionnaire filled by two of her daughters. In general, P1 listened to the songs without engaging in much eye contact with the investigator, with one hand under her chin, and from time to time adjusting her body to the chair, which is a common position for her. Also, she did not show behavioral changes when the music was over, in other words, she remained on the same physical position, which is consistent with behaviors observed during the MATADOC baseline. However, most of the songs (9 out of 12) triggered some responses on the participant while she was listening to the music, and these behaviors were: smiling, laughing, engaging in eye contact, nodding, foot-tapping, humming, moving her head to the music, and verbalizing. The song that triggered the greatest number of these behaviors was "Rock Around the Clock" with a total of 6 behaviors, even though her daughters informed that she did not listen or like rock and roll music. The songs "Jolene", "You are my sunshine", "Daisy Bell", and "Let me call you sweetheart", triggered at least three of the listed behaviors. The songs "She'll be coming round the mountain", and "Down by the riverside" triggered only one of the listed behaviors. The other four songs did not trigger any specific response in the participant. The behaviors triggered by the music were more frequent during the first minute of the song listening, tended to stop after, and sometimes retaken. During verbal follow-up P1 answered with smiles, nodding, with words like "yes", "no", word salads, clear well-made phrases, and good eye contact. As usual, her pragmatics during this interaction was appropriate (turn-taking, and eye contact). Most of her answers did not show a clear connection that what it was being asked it was connected to the song she just listened to. Many times, she did not answer the questions, or she said "yes" to open-ended questions. However, some cases for understanding could be made after listening to "Rock Around the Clock": "N: The name of this song is Rock around the... (waiting for her to fill-in), P1: rock and [word salad]...mock, N: Did you use to dance?, P1: No, N: Do you like rock and roll?, P1: No, N: Do you like this song?, M: Yeah". Some other interactions made sense within the conversation but did not imply connections to the song. This was asked after "I've been working on the railroad" which did not trigger any observable behaviors: "N: Did you like it?, P1: Yeah I liked it, N: Ok, here comes another song, P1: Another one?, N: Yes, do you want to listen?, M: Yeah!", or after another song "N: Do you want to listen more, P1: I don't care, N: Well, I care, P1: (laughs)". Another interesting interaction during follow-up was when options were given to her to choose between two artists and she was able to pick one: "what do you want to listen to now, Johnny Cash or Kenny Rogers? P1: (No answer), N: Cash or Rogers, P1: (No answer), N: Cash or Rogers, P1: Cash", however, she could also had been repeating back what it was said to her, and not actively making a choice. One last interesting behavior was that even she started feeling asleep at the end of the second to the last song presented ("Down by the riverside") she stayed awake and increasingly aroused with the last song presented ("Let me call you sweetheart"). It is particularly interesting as this is a sedative song, but the song kept her awake and humming aloud throughout the whole minute where the song was presented.

MATADOC After RS

Observed Responses at Rest

Pre-observational	Post-observational
Left hand on chin	Head movements: looks at the front, rotates to the center-left, left, up, and down.

Small movements of the head around the center and head rotation to left.	Trunk straightening and pushing trunk against the chair
Left hand adjusts shirt: includes upper extremity flexion/extension, finger dexterity and hand-eye coordination	Left hand scratches neck, touches nose
Trunk forward/back	
Left hand touches left ear, right leg	
Right hand movement touches the seat of the chair	

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Consistently tracked the visual stimuli. Followed stimuli in 3 out of 3 on all 4 quadrants. She attempted to grab the drum to see the picture.

Responses to auditory stimuli. Inconsistently tracked to auditory stimuli. Responded in 3 out of 8. Turned once with high pitch, stayed still on two occasions with both sounds.

Awareness of musical stimuli. Showed inconsistent interactive response within musical exchange. She hummed not very accurately to songs like "Rock of Ages" but filled in the blank with 3 correct cued words in "Holly Jolly Christmas". In the last one, the words were not correct, but the pitch was. She also followed the tempo tapping with her finger on her lap. To engage in all these behaviors, she had to be prompted with a question to reengage on the task of listening and actively participate.

Responses to verbal commands. Responded inconsistently to verbal commands. The command given was "touch the picture", she responded in one out of 6 attempts, where she reached to touch the drum but passed over the drum and touched my face. With a different object, a tone bell, in 1 out of 4 attempts she moved her hand, reached to touch but stopped before touching the instrument.

Arousal. Stayed aroused throughout the session.

Diagnostic Outcome. Score 7, Minimal Conscious State

Section 2: Behavioral Responses to Music

Same changes observed previously in the baseline. Changes in facial gesture through smiles and laughs during holly jolly which can be also the effect of interaction, successful responses, and positive reinforcement. Physical movement by tapping her finger to the rhythm of "Holly Jolly Christmas". Eye contact increased with the presentation of songs but sometimes was lost during the task. Hummed and completed cued words of songs which were a response to melody and form. The high loud pitch made her turn her head once.

Section 3: Clinical Information to Inform Goal Setting and Clinical Care

Same scores than baseline. Strengths in vocalization, attention to task, intentional behavior, and emotional response. Developing areas in non-verbal communication, choice-making, and motor skills.

Stimuli 3 - LMT

The whole procedure lasted 30 minutes and consisted of active techniques to promote: verbalization, social engagement, and following verbal commands.

The first application lasted 2 minutes and it consisted of playing the song "Daisy Bell" accompanied by the guitar to initiate the session and capturing her attention. After the song started P1 started hummed softly and inconsistently, looking away without engaging in eye contact. Before the second verse, the investigator gave her a command to look at him, which she did, and started singing a clear word "Daisy, Daisy". She kept consistent eye contact for the rest of the song (two more verses with the second one a whole step higher). During the song, she verbalized clearly at least 4 words cued at the end of a phrase. When the song finished, she was smiling and took 4 seconds before she laughed.

The second application lasted 6 minutes and 20 seconds and consisted of playing the drum to work on increasing responses to verbal commands. First, a drum was shown to her and a command was given to touch it, which she responded grabbing it, and then she looked away. The investigator said, "P1 look at me" and she engaged in eye contact again. The mallet was handed to her and she did not respond, but then with a verbal command, she grabbed it. The investigator said, "now play" and pointed to the drum. She took 4 seconds and started playing, she played for 5 seconds and stopped, the investigator laughed, and she laughed back. The investigator provided hand-over-hand assistance to play a steady beat while he sang the song "I´ve been working on the railroad". She sang correctly most of the words of the first verse, she mumbled others, kept the melody correct, although looked away few times, and needed verbal commands like "look at me" or the investigator had to move his head to find her gaze and engage her again. In the second verse, she kept eye contact consistently and said clearly most of the words. In the third verse, she looked down and only sang the last syllable of each verse, sometimes making the syllable longer but with the correct pitch. The investigator stopped the song there and said "yeah!" at the same time she smiled and laughed aloud. Then he said to her "now, shift hands", P1 put the mallet that was on her right hand to the left hand and back to the right, while her eyes were looking forward to the drum that the investigator was holding. The investigator prompted her to "say left" she answered "say maymen", the investigator insisted, and she said "mef". Hand-over-hand was provided for participant P1 to play a steady beat with her left hand, once she started playing on her own the assistance was discontinued and reinforced with verbal prompts like "keep going", and "go go go" paired to the rhythm. The investigator started singing, and P1 sang too singing the last word of each verse with a good pitch, she sang fewer words than the first time. In the second verse, she started playing slower and only sang the last vowel of each verse, still with good pitch and making eye contact with the researcher. In the third verse she sang the last words of each phrase but got distracted in the middle, the researcher provided hand-over-hand to reconnect her with the task and she continued. The researcher continued with the fourth verse and she was mumbling the melody with some correct words but did not play the drum. Another time hand-over-hand assistance was provided to keep her playing, but at the same time she started looking at her feet, the drum was moved to meet her gaze, but she moved her head to avoid the drum, although still singing, she filled-in the last word "banjo" but not played. The last command to "play one more time" was given to her while pointing at the drum, she played the drum and said "uuuuh!" while smiling and laughing. Immediately the drum was moved to her right and told her "play again" and she did not respond. The drum was then moved to her left, and she only laughed but did not follow the command, then it was moved up and did not follow either. More hand-over-hand assistance was provided while saying "play the drum" repeateP4y in rhythm and with a simple melody taken from the song, and she repeated the word drum. The drum was moved again to her left and the command was given again to her, she moved her hand with the mallet to play it but stopped before completing the movement, the command was repeated pointing at the drum, and she started playing the drum with her eyes looking at it. An improvised melody like the song was sung to keep her engaged on the task "Play play the drum P1 is playing the drum" where she continued for at least 15 seconds. The investigator told her "stop" and moved the drum to the left, but P1 continued moving her hand to the right as if the drum was there, she also kept repeating the song sung by the researcher but did not move her arm on her own to the other side to find the drum. Hand-over-hand was provided again to play the other side, she looked away and said "dray", the researcher repeated and emphasized the word "play" she looked at him once and then looked away again. The researcher said stop and she kept moving her hand for a while, then she said something in a word salad phrase, and after 7 seconds of saying this she laughed.

The third application lasted 10 minutes and consisted of singing the song "You are my sunshine" to increase the verbalization of target words in spoken form. First, the investigator held the hands of P1, swayed her arms to a steady beat, and started singing the song a capella. She kept eye contact for the first verse, and she sang all the words of the first two verses, on the third verse she looked down and only sang the last word "happy" making the last syllable longer. She did not fill in the last word of the fourth verse, therefore the investigator asked her "when the skies are what?", she did not answer, "Are they blue or gray?" and she said "blue", still looking down, the investigator repeated the question, she laughed and made eye contact, the investigator retook the melody of the fourth verse and she sang "are gray". For the fifth verse she sang the last word "dear", and for the sixth verse, she sang all the words, with no eye contact but looking to the front. For the last two verses, she looked down and sang many of the words although not all of them. This procedure of moving her arms to the music and singing was repeated a second time without giving her cues to fill in. She was looking down during the whole song, she sang some of the words correctly (especially the last words of each verse) and some others were mumbled, with less volume, but she kept the melody well. Then the melody of the song was played for her with the guitar, she did not engage in eye contact, and she started looking at her hands during the whole melody. The researcher gave her the command "now sing with me" and she did. She sang accompanied with the guitar keeping good eye contact. For the most part, she sang the last word of each verse. To finish the song the researcher made a ritardando breaking the last word in two, P1 followed this ritardando with her voice and filled-in with the last syllable. Immediately, the researcher said in a spoken form "You are my...", using the same rhythm of the song, pointing his hands at his chest, and raising the pitch at the end of the phrase while pointing his hands at her to fill in the word. She answered "yes". The prompt was repeated, and she answered a two-syllable word salad word. The prompt was repeated "You are my sun..." and she answered "shine". The same prompt was repeated for consistency and she answered saying slowly "my sunshine". After each correct answer the researcher celebrated which triggered a smile in her. The researcher continued with the rest of the song and the same cues "My only...", and she answered a word salad, "You make me ha..." and she answered a word salad phrase, then the investigator repeated the phrase but singing and she sang with him the correctly. He continued with the next verse in a spoken form saying "when skies are...", and she did not answer correctly in three attempts, then he sang the phrase and she answered correctly filling-in the word, he immediately asked in spoken form again using the same prompt, and she answered a two-syllable word salad. One more time he asked in a sung form and she answered correctly and in good pitch, he repeated the prompt in spoken form, and she did not answer just looked at him. He said to her, "say gray" and she answered, "say gray". The investigator continued with the next verse "you´ll never know..." and she said "Mary", he gave the command "say dear", and she said "over". Then, he sang the verse and twice she sang an incorrect word, but the third and fourth time she sang correctly "dear". He asked the same verse in spoken form and she answered "near", then another time she answered "ver", one more attempt she sang correctly. The investigator continued singing the next verse, and she correctly sang the word "you", and in a spoken form she filled-in correctly in 2 out 4 attempts. The investigator continued singing the last two verses "please don´t take my..." and she answered incorrectly mumbling word salads in 3 attempts, before the fourth attempt he said "sing with me, please don´t take my..." and she sang "sunshine away" with good pitch. Finally, the investigator played the song on the guitar and said, "now you sing" and waited for her to sing the whole song on her own. However, she only sang when it was cued by him by singing the beginning of each verse, and she did sing a whole phrase, making up all the words but maintaining the melody. When the song was over, she made eye contact for one second and then looked away.

The fourth application lasted 5 minutes and 28 seconds and the goal was to increase the response to verbal commands through singing and modeling. The song "Down by the riverside" was presented to P1 with the guitar, in front of her, by singing the first verse and the chorus. While the song was presented, she stayed seated with her hand under her chin looking to the left (usual physical position), and without making eye contact with the researcher. Immediately, the researcher stopped the guitar and changed the lyrics to "Gonna clap my hands, clap my hands, clap, clap, clap clap my hands" using the same repeating melody and modeling the movement. She responded engaging in eye contact, clapping her hands, and repeating the word "my hands". Her clapping was sounP4ess and a few seconds later she started looking down, without stopping the movement. The researcher provided hand-over-hand assistance for a few seconds to help her clap in rhythm and to connect her gaze without stopping his sing. Then, she continued clapping on her own while repeating the melody sung by the researcher and only saying clearly the words "hands", and she continued looking at the researcher who was clapping and singing. The researcher changed the lyrics to "raise your hands, raise your hands, raise, raise, raise your hands" and modeled the movement. Her eyes tracked the movement of his arms and she followed raising her arms while mumbling the melody, though she sung the words "raise your hands" once. Without pausing, the researcher changed the lyrics to "tap your lap, tap your lap" and modeled the movement. This time she did not follow the movement but kept mumbling the melody while engaging in eye contact. The researcher provided hand-over-hand assistance to tap her lap, which she continued doing on her own, mumbling the melody but still saying "hands". The researcher changed the command to "clap your hands" again maintaining the melody, she kept tapping her laps for five seconds, and after five more seconds she started clapping, she did 3 claps in rhythm and stopped while looking down. The researcher grabbed the drum and sang repeateP4y with the same melody "touch the drum, touch the drum". She only looked at the drum mumbling the melody, and the researcher kept singing while touching her hand and pointing to the drum. The researcher stopped the singing and said: "P1 touch the drum". She did not follow the command until he provided a slight force over her hand towards the drum when she touched it, then she looked at the researcher and said "Yeah". For consistency the researcher took the drum out and gave the command again saying, "P1 touch the drum", and she did not respond. The researcher provided tactile priming with her hand over the drum, while singing and chanting “touch the drum" for one minute. He stopped the music and he gave the command three more times, but she did not follow although she kept good eye contact.

The fifth application lasted 4 minutes and 17 seconds and consisted of instrument playing to increase response to verbal commands. The researcher presented two shakers to P1 by playing them in front of her. She looked at him and said "oh!", then a word salad phrase, and then laughed. He handed the instruments to her, but she did not move to receive them. The researcher put one shaker in each of her hands and with hand-over-hand assistance shook them together repeating the word "shake". She continued moving her hands on her own but slowly and without making the instrument sound, then she put her hands together. The researcher stopped and separated her hands, and with hand-over-hand assistance, he shook them separately. This time she responded shaking the instrument for only two seconds. Immediately the researcher started playing with the guitar and singing the song "Shake rattle and roll". She looked down for the whole first verse and chorus, then the researcher, without stopping the guitar verbally gave the command "P1 shake it!". She responded by looking at her hand and grabbing both shakers with one hand like preparing them for the movement, then the researcher chanted "shake it" repeateP4y with the music, and she responded shaking the instrument. The researcher sang the chorus again that says "I say shake rattle and roll", and she continued for a total of 20 seconds, although looking away. The researcher sang the second verse introducing a silence in the accompaniment which made her stop shaking and look at the researcher back again. Then, he continued singing the second verse and when the rhythm was back, she shook the shakers again but only one second. When the chorus was back again, she took 5 seconds to start shaking again but only for 5 seconds, she also was moving her lips as if she was singing, however, her eyes started looking away again. She stopped shaking and the researcher gave again the command repeateP4y "shake it". She responded repeating the word "shake it" one time and shaking for 5 more seconds, stopped again and put her hand down. The researcher stopped the harmony, strummed the guitar muting the strings with his palm, and sang the chorus again introducing the "shake it" verbal command. She responded singing the "and roll" part of the chorus, still looking away. The researcher started clapping the rhythm, and she responded clapping with the shakers, the researcher provided 4 seconds of hand-over-hand assistance shaking with her, but she did not continue the movement but made eye contact, the researcher finished the song, and 4 seconds later she started laughing still making good eye contact. Once the song was over the researcher said verbally "P1 shake it" pointing at the shakers in her hand, and she responded handing them to him. Then he said again "shake them" and modeled the movement and she followed without stopping, even when he said "now shift hands" she continued shaking. Then he said and modeled "shake high" and she followed and said "high", then he said, "shake low" and modeled but she only lowered her arm a couple of inches. Then he stopped the movement for her, and said "now shift them to the other hand", and assisted her to pass them, but even though she was looking at her hands and her right hand was open, she did not release them from her left, and actually, her eyes were pointing to her right hand. The researcher put them in her right and said "P1", she said "what?", and he gave the command again "shake it", she followed shaking them softly for 2 seconds, laughed, and said, "oh my goodness".

The last song was presented to close the music therapy part. The song was "This land is your land" and lasted 35 seconds but P1 started sleeping. The song was discontinued, and P1 was wakened up to start the MATADOC evaluation.

Finally, out of the MATADOC procedure, once the researcher finished picking up all the material and was ready to leave, he woke up her to say goodbye, she opened her eyes and said: "thank you". This was the only time she said those words.

MATADOC After LMT

Observed Responses at Rest

Pre-observational	**Post-observational**
Head movements (down, center, right)	Left hand under chin
Small finger movements	Trunk forward/back
Trunk forward/back	Small head movements
Left hand reaching to her back	Right finger movements
Hand rubbing, hands separation/together	Left leg small movement
Verbalization (word salad question)	Eyes closing
Face expression change (question face)	Eyes opening
Eyes tracking in all directions	Sleeping with trunk and head falling
Trunk to side	

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Consistently tracked the visual stimuli. Followed stimuli in 3 out of 3 on all 4 quadrants, at 1 and 2 feet.

Responses to auditory stimuli. Inconsistently tracked to auditory stimuli. Responded in 3 out of 10. Turned her head with the high pitch, moved away with the low pitch, and moved the trunk with the rhythm of the drum all these to the right side.

Awareness of musical stimuli. Responded for the duration of music only. Hummed softly, infrequently, and inaccurately to "Oh Susanna", and moved her head to the music with the chorus of "Ring of Fire".

Responses to verbal commands. Responded inconsistently to verbal commands. Followed commands in 2 out of 7 attempts without additional cues. She did not follow the command "touch the drum" but was more successful if tactile cues were added. The same behaviors occurred with the shaker using the left hand, she did not follow the command "shake them" but was more successful when modeling was added. Finally, she followed this command twice using her right hand with no cues added.

Arousal. She stayed aroused throughout the session, although she appeared sleepy at the end of the session.

Diagnostic Outcome. Score 7, Minimal Conscious State

Section 2: Behavioral Responses to Music

Same changes observed previously in the baseline. Changes in facial gestures through smiles and increased eye contact during introduced silences as a surprise element within the music. Increased eye contacts also during songs played a capella with tactile stimulation (arms waving to the music). Physical movement by shaking shakers when prompted. Vocalization with humming to both songs presented. Arousal increased during song presentation.

Section 3: Clinical Information to Inform Goal Setting and Clinical Care

Same scores than baseline. Strengths in vocalization, attention to task, intentional behavior, and emotional response. Developing areas in non-verbal communication, choice-making, and motor skills.

APPENDIX C: MATADOC BASELINE REPORT, NARRATIVE OF CONDITIONS AND MATADOC POST-TEST REPORTS FOR P2

MATADOC Baseline Report

Observed Responses at Rest

During the pre and post, behavioral observation periods of each assessment session P2 demonstrated several positive behaviors during periods of no stimulation. It was common to see constant tremors with her open and closed mouth. Rotating movements of the head to both sides, usually towards where the assessor was and sometimes making eye contact with him, suggesting good peripheral vision, but it also appeared that she was tracking the room with her eyes. Movements of the trunk like leaning forward/back and pushing it back against the chair. Upper extremity movements like holding to/resting on the armrests, rubbing knee, touching/holding parts of the wheelchair, touching her face or neck, grabbing the straps of the fabric of the chair with both of her hands, and playing with a doll. These last two movements were complex in nature and included bilateral integration, finger dexterity, and hand-eye coordination. Movements of the lower extremities were also observed but were less frequent. Talking behaviors were frequent, she talked to the assessor, herself, or with the doll, and this was most common for the post-observational period (4 out of 4) than for the pre-observational period (2 out of 4). Sleeping behaviors were only observed once during the pre-observational period.

Session 1

Pre-observational	**Post-observational**
Hands together	Mouth tremor
Head rotation to L, R, C.	Talks/replies
Mouth tremor	Trunk forward
L and R hand/arms grab/lie on armrests	Head rotation to L and R
R hand grabs straps from the chair	Trunk back
L hand touches nose	Grabs strap of wheelchair
R hand rubs knee	Leans forward reaching down with L hand

L wrist movement	

Session 2

Pre-observational	**Post-observational**
Right hand to mouth	Talking to doll
Right hand on the armchair	Holds strap of the wheelchair with both hands
Eyes closed	Head rotation to R
Eyes opened	Looks at doll
Mouth tremor	Takes doll to mouth
Head rotation to R and C	
Talking	
Coughing	

Session 3

Pre-observational	**Post-observational**
Head rotation to R, C, L, down	Head rotation to R, C, L
R hand to chin/neck	Talking
Mouth tremor	Holds/hugs doll with one or two hands/arms
L fingers move on the strap	Sings to doll
Both hands holding strap includes finger dexterity, bilateral integration, and hand-eye coordination	Trunk forward/back
Both feet movement	Reaches with arms and touches the metal part of the chair close to legs
Trunk forward	Kisses doll
R hand touches R leg	Plays with doll
Trunk back	Mouth tremor

Session 4

Pre-observational	**Post-observational**
Grabs strap of the chair with one or two hands	R leg up
Yawning	R and L foot movements while looking at them
Head rotation to R, C, L	Trunk forward
Mouth tremor	The arm reaches R foot
Hands together on lap	Talking
Talking	Trunk back
R hand to face/mouth	L hand to eye
L hand to face	Head rotation to R, L
L feet movement	Both hands hold sides of the wheelchair
Both arms on the armchair	Pushing back the trunk against the chair

Eyes tracking the room	Grabbing doll with one or two hands
Hands held together	Mouth tremor

MATADOC Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Pictures of significant and well-known musical stimuli were used using images from Julie Andrews from the movie "The Sound of Music", Dolly Parton, and Glenn's Miller Big Band. These stimuli were presented at approximately 1 to 2 feet from her eyes. In all the 4 sessions she consistently followed the stimuli on the 4 quadrants (Left, Right, Up, and Down). However, sometimes she needed prompts to kept her engaged in the task, these prompts consisted of asking her questions about the pictures or simply by telling her to keep looking. Many times, either during the visual tracking task, or instrument playing, or during verbal commands, she looked both at the assessor and to the visual stimuli alternatively, or the two instruments presented simultaneously, therefore, categorizing for the higher score.

Responses to auditory stimuli. Guitar playing and singing were presented in P2's midline. During this task, she kept consistent eye contact with the assessor, remained silent, and intervened with comments when the song was over, or in-between silences (like before the chorus), showing active listening behaviors. During a second task of tracking auditory stimuli, different instruments were used: tone bells (A3 and D#6), tambourine, keyboard, and egg shakers. These stimuli were presented close to the ear with a dynamic from soft to loud and outside of her visual field. She rarely turned her head towards the stimuli, and a common response was vocalizing sounds of agreement ("hm-mmm") when the sound was stopped by the assessor. Therefore, the assessor included a question to check if P2 heard the sound and where. With this question, she responded with "yes" and "no", and pointing with her hand where the sound was, not always adequately, but much more connected to the task. In session 4, using the tone bells it was asked for her to discriminate if the pitch was high or low. In 7 out of 8 attempts she said that the pitch was high, only once said that the low pitch was "medium", and when the high pitch was played, she said it was "higher". She categorized for inconsistent responses to auditory stimuli. However, by asking her to produce the auditory stimuli for herself, like giving her the egg shakers to shake is close to each of her ears, she consistently said when she was hearing or not the sound, considering that she was deaf from the right side. This last procedure was performed outside of the standardized protocol and should be considered anecdotal in the context of this assessment.

Awareness of the musical stimuli. P2 showed consistent interactive responses when instrument playing was offered as a task, which occurred in sessions 3 and 4. First, she was prompted to play the keyboard on her own, playing no more than two notes, and verbally stating that she could not play anymore. However, when the assessor accompanied her keyboard playing using the guitar, she improvised melodies for much longer: 40 seconds ins session 3, and 1 minute 35 seconds in session 4. Her playing showed finger dexterity and attempted to play specific movements (arpeggios and scales). The duration of her playing suggests that she was interactively playing with the support of the guitar and the chord changes produced by the assessor. Another instrument used was the drum, which was given to her in session 4. On her own, she played rhythm in 4/4 repeating it twice and then played eighth notes. Then, the assessor prompted her to follow his singing of "My Favorite Things" a song in 3/4. She began playing after the assessor started singing and produced accents at the beginning of each new verse, matching the tempo and rhythm of the voice, and showing consistent interactive responses.

In sessions 1 and 2 only singing was used during song presentation. She sang most of the words of the song "I've been working on the railroad", and some from "She´ll be coming round the mountain" matching the key and tempo of the assessor. She filled-in the last word of some songs like "KKK Katy", and "This Land Is Your Land", and sung the first two words of "Oh Danny Boy". However, it was noticed that her rate of speech was slow, and it could have been interfering with the flow of singing too. The low participation in singing in these two sessions was rated as showing inconsistent interactive responses.

Response to verbal commands. P2 responded consistently to verbal commands in all 4 sessions. She responded successfully to different verbal commands like "touch the drum", "shake the shakers", "shake them loud", "shake them soft", "shake them high", "shake them low", "shake it with the left", "touch the drum", "pull a string", "pull another one", "touch the white one", and "touch the black one". Some few times she did not respond to the command and it had to be repeated and one time including tactile priming. Some other times she followed- up asking back what she heard, which allowed the assessor to state the command again, this time louder and clearer. For example, one time she heard "dutch" when the command was "touch", and another time she heard "then" when the command was "left", which suggests a hearing loss in the higher frequencies. Nevertheless, her ability to respond to verbal commands was unimpaired.

Arousal. P2 stayed aroused throughout the sessions in all 4 assessments, where she actively participated in all tasks requested. She was usually very talkative, except for the last assessment where she seemed a little off than usual, and more tremors were observed. However, her arousal and her amount of talking increased after song presentation.

Diagnostic Outcome. P2’s scores were congruent with the presentation of someone in Higher-Level State. In the 'Essential Categories Principle Subscale' over the four MATADOC assessment sessions in the response categories (visual, auditory, awareness of musical stimuli, verbal commands, and arousal) P2's total scores were: Session one: 8 (Higher-level state), Session two: 8 (Higher-level state), Session three: 9 (Higher-level state), Session four: 9 (Higher-level state).

MATADOC Section 2: Behavioral Responses to Music

P2 showed several positive responses to music. Changes in facial gestures like smiling were observed after she hit the high tone bell, or when she heard the shaker to her left compared to her right, which could be a response to timbre, or after songs that she identified like "KKK Katy", "I´ve been working on the railroad", "This Land is Your Land", "Oh Danny Boy", and "She'll be coming round the mountain", which could be a response to melodies. Changes in eye contact and eye direction was observed during all song presentation and instrument playing as a response to interacting with the assessor through melody, rhythm, and form. Changes in physical movements of the upper extremities were observed during the requested instrument playing, responding to timbre, rhythm, melody, and form. Nodding of the head was observed when recognizing a song as a response to a melody. Changes in vocalization through humming, singing, and filling in the blank during song presentation was a response to melody and form. She usually verbalized words immediately after song presentation, and once mentioned that the recorded music was "too loud", as a response to dynamics. Changes in arousal were observed through increased talkativeness after song presentation as a response to the melody.

MATADOC Section 3: Clinical Information to Inform Goal Setting and Clinical Care

All the areas covered in this section were rated as strengths for P2, except for motor skills that were rated as a developing area, although being the highest possible level of the assessment. Vocalization responses ranged from inconsistent vocal sounds to stimuli to sing the last words of phrase that acted as a cue. These responses were observed mostly after prompts like "sing with me" or leaving spaces at the end of a phrase for her to fill in the blank. She hummed to "Amazing grace". She sang the first two words of "Oh Danny Boy". She filled-in the last word of "KKK Katy", and "This Land Is Your Land". She sang most of the words of "I've been working on the railroad" singing a capella with the assessor and using tactile cues by waving her arms to the tempo of the song. When asked to sing "Danny Boy", she said that she "lost all the words", she could not sing because she did not know the words anymore. Non-verbal communication was rated high as she showed consistent use of spontaneous and appropriate social communication gestures. Her responses included head nodding when recognizing a song or the person in the visual stimuli, interactive eye contact during conversations between tasks and instrument playing, active silences with eye contact during music presentation, use of hand gestures to reinforce verbalization or as communication like pointing with the finger to show where the sound was or playing an imaginary violin to say violin. In choice-making, she communicated her preference between two objects in 3 out of 4 sessions. The only time that she did not state a preference was in session 2 when she was asked if she preferred the drum or the guitar, answering that "either is fine". In all the other three sessions she communicated her preference between two instruments. In session 3 she stated verbally her preference, being the piano preferred over the guitar and the violin. Nevertheless, the question had to be asked again several times for her comprehension, probably due to hearing loss. In sessions 1 and 4 she pointed at the instrument of her preference, being the guitar over the drum, and the piano over the guitar. Attention to task, she participated actively throughout the entire session, lasting 30, 40, 42, and 45 minutes each session from the first to the fourth. One of the reasons that the sessions took longer than usual was because she was very talkative, her rate of speech slow, and her verbalizations listened, followed-up, and validated by the assessor. Intentional behavior was rated high as her responses were evident and achieved a goal. These behaviors were singing words, playing repeated rhythms on the drum, different types of movements on the shakers, and scales and melodies on the keyboard. Emotional responses were frequent, contingent to stimuli, and observed on more than one occasion. These responses included smiling when recognizing songs like when the chorus from "KKK Katy" started, or when the person from the visual stimuli was mentioned like Dolly Parton or the movie "The Sound of Music", or when she made a sound on the high tone bell hitting it with her nail. She also smiled when she heard the egg shaker shaken on her left ear after being played on her right, recognizing her increased ability to hear on the left side. After improvising with the keyboard, she smiled with her mouth wide open at the same that she opened her arms wide like saying "that's it". She verbally said, "that's good" after hearing a catholic song most probably unknown to her called "Oh Lord You Have Come To The Lakeshore". Motor skills were rated high showing spontaneous purposeful independent movement observed on her upper extremities when she played instruments like the drum by holding a mallet, keyboard playing with finger dexterity using her right hand, pulling a string of the guitar, and shaking the egg shakers or the tambourine with both hands and controlled arm movements.

Relations Between the MATADOC, the GDS, and the CDR

P2 was assessed using the Clinical Dementia Rating Scale by the Student Music Therapist. During the interview for the CDR scale, she was very talkative and able to talk about the distant past. She rated a total score of 3, which means a severe state of dementia. She scored severe in orientation, judgment, and problem solving, homes and hobbies and personal care, which means that she was only oriented to person, unable to make judgments or solve problems, with no significant function at home, and required much help with personal care and was incontinent. The only two areas where she scored moderate were in memory and community affairs, which means that although she showed severe memory loss, highly learned material was retained, and new material was rapidly lost. Also, she appeared well enough to be taken to function outside a family home, with no pretense of independent function outside a home.

Using the GDS which gives a rough description, she scored a 6, being moderately severe. However, the description did not adjust totally to her case, except for the retaining of knowledge from her past, severe short-term memory deficits, unawareness of time, recalling of her name, and delusional behaviors. It did not fit was that, for the most part, she was not able to distinguish familiar from unfamiliar people or locations anymore, and that she was fully assisted with ADLs, although able to eat simple solids with supervision, and had total incontinency.

Interestingly, only her ability to localize auditory stimuli and level of vocalization showed deficits in the MATADOC, and all the other areas showed a high level of response. It calls up the attention of how playing musical instruments was still connected over a minute despite her short-term memory deficits. Therefore, the high level of awareness defined on the MATADOC showed many strengths in several areas of function that could help to maintain her physical, emotional, cognitive, social, and spiritual areas, despite her moderately severe level of dementia.

Results and Recommendations of the MATADOC Assessment

MATADOC outcomes indicate that P2 was responding at a Higher-Level State of awareness. She demonstrated consistent awareness of herself and her environment, only slightly diminished in her ability to track auditory stimuli in the absence of visual or tactile cues.

Comparing the pre-observational period with the post-observational a trend to increase talking behaviors was observed after the protocol, but no other significant changes were observed.

During the assessment, she showed a high ability to visually track more than one stimulus presented at the same time, consistent interactive responses within musical exchange when playing instruments like the keyboard or the drum, high response to verbal commands and high arousal. She showed responses to different elements of music like melody, rhythm, dynamics, timbre, form, and tempo, that produced behavioral responses like smiling, maintain and switch eye contact, fill-in words, move her upper extremities, and increase her arousal through increased talkativeness. She showed some ability to recall words of well-known songs, high response in non-verbal communication through hand gestures and head nodding, ability to make choices between two objects, purposeful movement of upper extremities, high attention to musical tasks, intentional behaviors like singing and playing music, and emotional responses through smiling and verbally stating her liking of music.

In conclusion, P2 did not show deficits in awareness, therefore her cognitive deficits should be addressed to other areas most probably to orientation to reality, short-term memory, lexical memory, and hearing loss. Her high responses in a musical context suggest that music therapy is highly recommended to work on maintaining her cognitive, spiritual, emotional, physical, and social areas. Including her family to further connect with her could be highly beneficial too to improve her quality of life and from her loved ones.

Stimuli 1 - RS

The procedure lasted 22 minutes and consisted of listening to 6 songs, and after each song, the researcher followed up with P2 asking her questions about the songs. The music was delivered by headphones and in mono setting, to provide all the instruments to the left side, which was her functional hearing side. The songs presented were: "Oh Danny Boy" sung by Judy Garland, "Too Ra Loo Ra Loo Ral" sung by Katie Smith, "Edelweiss" from the movie "The

Sound of Music", "I've Been Working On The Railroad" sung by Pete Seeger, "My Wild Irish Rose" sung by Dennis Day, and "KKK Katy" sung by Billy Murray.

When P2 was brought into the room she said to the researcher "I'm afraid [unintelligible phrase] for play, because I know all of them". The researcher said "I know you know all of them, don't be afraid. Today I brought you some songs that I know you love, listen well".

The first song played was "Oh Danny Boy". Twelve seconds after the song started, she said: "I know they didn´t do it... because I know where they were and that they are honest kids, it's a police car that just ran by". The investigator asked her louP4y "Do you hear?", and she answered "Yeah, I have a hearing orchestra, no, a hearing [other unintelligible], and I saw you... those... that's my [unintelligible word]... I missed the tone. I think... Oh, that's her brother. She [unintelligible phrase]. I can't hear". She said the last sentence when the music was over. The investigator asked her "what song was that?" and she said, "that's the ba... ba... baba (sic) and they are all hating the kid". The researcher asked her "I just showed you a song, did you hear the song?" and she furrowed her eyebrows and closed a bit her eyelids, like saying *I am not sure about that.* All these first verbalization appeared more connected to something she was thinking before the session began.

For the second song "Too Ra Loo Ra Loo Ra Loo Ral" the researcher prepared the audition by asking her "Do you know Kate Smith?", she answered "no", and he said, "she is a singer, I will play one song from her, listen well". She remained silent for 1 minute and 10 seconds looking at the notes that the researcher was writing in front of her. He stopped writing and closed the book, and a few seconds later she said: "I can´t agree with you". This sentence coincided exactly with the ending of the chorus of the song. Eight seconds later she said "we lived together for a... nine years... I´m... I´m nine years...and she is nine years too, and we went to Simpson Church, where.... nine years... and we had no nothing... and, I can´t... I just can´t [unintelligible words] because I know all". This last sentence was said when the song was over. The researcher took the headphones out from her head and said "P2, I just showed you another song called Too Ra Loo Ra Loo Ra Loo Ral, do you know it?" and she said, "Well, was that [unintelligible word], wasn't it?".

The researcher continued with the third song saying "this is another song from the movie The Sound of Music, it is called Edelweiss. I will put this on your ears (hand-over-hand touching headphones) so you can listen to the song". This was a 1 minute 35 seconds excerpt of the song. During the song, she remained silent holding the headphone with her right hand. Immediately when the song was over, she said: "I better not [unintelligible word] you?". The researcher took the headphones out and asked "P2 did you hear the song?" and she said "yeah", he asked "what was it?", and she answered, "a doggie". He continued asking "who was singing a man or a woman?", she said "I don't know", he asked "Do you know the song Edelweiss?", and she answered "no", then the researcher sang the beginning of the melody and asked again if she knew the song, and she said that she did not.

The fourth song was "I've been working on the railroad" and this time the researcher increased the volume. After 51 seconds she said, "that's pretty loud", and the statement coincided with the end of the second verse. The researcher immediately decreased the volume for her. Eighteen seconds later she said, "then your m... family know what you´re just saying...". The researched nodded yes and she said "well ok" while nodding yes too. When the song was over, she immediately said: "that was beautiful". The researcher took the headphones out and asked her "That was what?" and she did not answer, and he continued asking "I just showed you a song, did you hear that?" she took her head and mumbled an unintelligible sentence. He then said that the song was "I´ve been working on the...", and she said "no".

The fifth song was "My Wild Irish Rose" and before playing it the researcher said, "I know that you used to play this song with the organ". Seven seconds after the song started, she said "too loud", and the researcher decreased the volume, she followed-up saying "there". The first sentence she said coincided with the ending of the first musical phrase played by the violins from the introduction of the song. Forty-one seconds after the song started, she changed her face expression furrowing her eyebrows and said, "oh boy" and this coincided with the ending of the first verse. She listened to the song in silence for a total amount of 2 minutes and 22 seconds, then she took the headphones out of her head, which coincided with the ending of the chorus that was repeated a second time and had a ritardando. The researcher asked her "are you ok?" she said "yeah", "what song was that?" he asked, and she answered "I've never heard", and he continued "Was it a beautiful song or not?", and she answered, "I have to go home". Then she looked at the clock on the wall and said: "yeah 5 minutes".

When the researcher tried to put the headphones again, she said: "Oh I can't my mother and my dad are waiting". The researcher validated this statement saying "Your mom and your dad know that you are all right, you are safe, don't worry. This is another song called KKK Katy", and he put the headphones on her and started the song. Thirty-five seconds after the song started, she began to cough without stopping. The researcher offered her water, but she was looking down and could not hear because of the music and the cough. Her face showed signs of discomfort, she said "I'm falling", and continued moaning. Therefore, the procedure was immediately discontinued, the music was stopped, and the headphones removed. She said, "I have to go home" and continued coughing. The researcher touched her arm and said, "P2 look at me, you are all right, here, drink some water" and she sipped with a straw, and slowly her face expression came back to normal. She continued coughing a little more, and the cup of water was given to her, so she could control the amount of water she needed. In less than two minutes she came back to normal. The procedure was stopped altogether 7 minutes before what was expected.

MATADOC After RS

Baseline Responses

Pre-observational	Post-observational
Mouth tremor	Trunk forward/back
LH rubs doll's head	R arm reaches ankle (to grab a strap)
Holds doll with LH and/or R arm	Holds doll with LH
Turns doll up with LH	Grabs strap with RH
Takes doll to touch her face	Manipulates strap with both hands. Includes hand-eye coordination and finger dexterity. At the same time is holding strap with LH.
Sings to doll	Mouth tremor
Hugs doll	L arm on the armrest
A small movement of feet	Holds doll with R arm and close to the chest
Lifts feet	Chin forward touching doll's head
Head rotation to L, R, C	Hands resting together while holding strap
Holds strap with LH	Talks softly and smiles to the doll
Trunk forward/back	Kisses doll
RH to touch face and hair	

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus alternatively on more than 1 visual stimulus, when playing the keyboard accompanied by the assessor. Same as the baseline. Although she tracked only in 3 of the quadrants, not up, and did not reengage with prompts.

Responses to auditory stimuli. Inconsistent eye/head movement/turning towards auditory stimuli. Same as the baseline. She leaned her head to the right with the egg shaker in 1 out of 2. Did not turn in 4 attempts with the tone bells, but spoke a sentence once after hearing the lower tone bell saying "I can't sing, I just can't"

Awareness of musical stimuli. Showed inconsistent interactive responses within musical exchange. Like baseline. She played the keyboard while the assessor accompanied her with the guitar. She played a descending scale first with 3 white keys, then moved down to the black keys until reaching the last lower black key of the keyboard. She played for 54 seconds and compared to baseline when was asked to play on her own, considering the duration of her playing, it seemed that she was playing supported by the sound of the guitar. However, it did not appear to be a musical interaction with the assessor, rather she was following a motor plan she already had. After finishing the assessor validated her playing with positive reinforcement, and she said: "I wouldn't call it playing, we called it to play the last".

Responses to verbal commands. Consistently followed verbal commands. Same as the baseline. She followed different commands "touch the drum", "shake the shaker", "shake it to your ear", "shake it high", and "shake it low". She did need tactile priming to understand the command "touch the drum".

Arousal. Aroused throughout the protocol. Same as the baseline. No noticeable changes in arousal.

Diagnostic Outcome. Score 8, Higher-level state.

Section 2: Essential Categories Principles Subscale

Like baseline, but low considering maximum achieved in baseline sessions 3 and 4. Probably due to reduced duration of the session and negative effects of cough attack. Only one facial change, a surprise face expression when presented with the visual stimuli during visual tracking task. Eye contact and eye movement during keyboard improvisation where she showed good hand-eye coordination as a response to melody and rhythm played on the guitar. Physical movement changes when she played the keyboard during improvisation as a response to melody and rhythm; touched the drum and played the shakers after verbal commands; head leaning towards the egg shaker as a response to timbre, and head nodding when recognized the song "KKK Katy" after the chorus, this as a response to melody. Changes in vocalization when she filled-in the blank once during "I've been working on the railroad" as a response to melody and form.

Section 3: Essential Categories Principles Subscale

In the vocalization item she sang the last word of phrase that acted as a cue. Same as the baseline. She filled-in the blank with the word "horn" on *"I've Been Working on The Railroad"*. She repeated back once the words "KKK Katy" when prompted to sing the chorus of the song with the same name.

Non-verbal communication: Consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. She communicated using hand gestures to reinforce verbal communication, interactive eye contact during instrument playing, head nodding to show agreement.

Choice making: Looked toward more than 1 object presented simultaneously. Like baseline. When asked what she preferred guitar or drum she looked at both but did not state a preference.

Motor skills: Spontaneous purposeful independent movement. Same as the baseline. She shook shakers with both upper extremities, and played keyboard with her right hand, crossed midline, and moved her trunk forward to reach the last key to her left

Attention to task: Attended for the entire session. Same as the baseline. Participated actively during the 18 minutes of the session.

Intentional behavior: Intentional response evident with the goal achieved. Same as the baseline. Played a descending scale with the keyboard to reach the last note, then verbalized this saying "we called it playing the last".

Emotional Response: Changes in expressive behaviors related to stimuli on 1 occasion. Lower than baseline. Only showed one change during the presentation of visual stimuli, where she responded opening her eyes more and saying "oh", showing surprise.

Stimuli 2 - ASPT

Messages were recorded by the daughter of P2 and the procedure with P2 lasted 25 minutes. The procedure consisted of listening to recorded messages and then following-up with questions made by the researcher. The questions part lasted much longer than the listening part. The messages were delivered through a speaker, considering that in the last session she had a cough attack and had difficulties connecting and alleviating her symptoms probably due to the isolation produced using the headphones. A hearing test was performed first to check if she could hear well. The first sentence of the first message was played for her and the researcher asked her "Did you hear that person?", and she did not respond. The questions had to be asked again twice and she said, "Yeah I heard it", the researcher followed-up and said "She said hi mom this is K", and she answered back "Oh, I heard she said head up". For this reason, the speaker was given to her to be held with her left hand, and told her to hold it close, but not too close to her left ear.

The first message lasted 3 minutes and 21 seconds and it was about the stories that P2 had with horses. She listened in silence and her eyes were looking towards the speaker for the most part, but she also looked at the researcher who was in front of her, and at her doll that she was carrying on her right arm. She said "hmm-mmm" (like saying yes), on a pause where her daughter was describing one of the horses being stubborn. On the follow-up, the researcher took out the speaker and said to her "so, horses, uh?", she smiled and laughed and said "yeah". The researcher asked, "who was Patches?", and she said, "I don't know", then he asked her "Well but patches was your horse, right", and she said, "oh yeah". Then the researcher said back to her parts of the message for her to confirm or respond in three other times. She tended to answer "no", "I don't know", or elaborated an empty answer, therefore she only connected one answer with the original message or with her memories.

The second message lasted 2 minutes and 11 seconds and it was about P2 main job. She listened in silence looking consistently to her left down, and only looked once at the researcher. When the audio was over, he took the speaker from her hand and then she looked at him and asked "Can I just sit, and watch, or walk? That's what I used to do". He followed up and said, "tell me more", and she said, "I... didn't like it... lock (cough), and I did lock it and didn't say anything". He continued asking "What did you use to do?", and she said "Just parallel well", and he said "Parallel well with them?", she said "no", and he asked "Are you talking about your job?" and she said "no". The researcher said back to her what was used to be her position and main job, and she said "oh yes", he continued asking "what did you do there?", she answered a word salad sentence, coughed, and continued saying "the reason I left was... pillow column, there, then he called... I... I... I... can´t go invented in that, they... didn't". He validated her answer and continued asking about two people that were mentioned in the message well known by her, but she did not respond in any particularly interesting way.

The third message lasted 2 minutes and 18 seconds and it was the continuation of the second message, but it was more related to leisure activities, and friends in her job, and finished telling why she retired. She listened in silence still looking to her left down and looked to her doll twice for no more than a total amount of 5 seconds. When the researcher took the speaker she said to him "that was exactly how it was done", he said "tell me more" and she continued "Tired, retired, re...uh, they, we got new vestments (sic), and... he announced [unintelligible word] Sunday did that, and he goes to Greek, and nothing, paid a house to... sometimes, he asked her, he says, he has a something, and [unintelligible words] wouldn't it bring my man... and... I think... he filled something... on an... interior... that, uh...we wanted for the hehe (laughs) them want to tell... [unintelligible sentence] ... they didn't have what you call... environment lock indoors retake". The researcher continued asking "tell me something about these trail rides, did you use to go on trail rides?", and she answered, "that was... a lot of my mode... boys... but it wasn't a price". The researcher asked, "And what about Mary Smith?, who's her?", she immediately smiled and nodded yes, and he continued saying "I see you smiling, did you use to go on trail rides with Mary?", she nodded yes again and said "A-ha, yeah", he followed-up asking "where did you go?" and she said "she isn't catholic", and he said, "but you are?", and she said, "oh yeah". The researcher changed the subject and asked her "what about your children? how many children do you have? three or four?" and she answered "three".

The fourth message lasted 1 minute and 40 seconds. It consisted of how she met with her husband when she was in school, and how she left the school for girls because she thought everyone was a snob. She listened in silence looking down to the front and brought the doll close to her chest occasionally rubbing its head. When the recorded message was over, the researcher asked, "Was that so?" and she said "Oh yeah", then she took the doll up to her face, looked at it and said smiling "You were girl nob (sic), now?". The researcher continued asking "You met your husband during high school?", she said "oh yeah", he said "tell me more", and she continued "we were a couple of boyfriends... and he played... baseball and basketball, and that's how I got crushed, just, he got into it, because in Bloomington he had... he [unintelligible words]". The researcher continued asking "and what about Saint Joseph College for Girls, who went there?" and she said "no", he asked again in a simpler form "Did you go to Saint Joseph's" and she said "I sure did... but they, go... it's in Peoria... you get out of... high school and you can go to Peoria". The researcher asked her three other questions related to the message, but she did not connect an adequate answer.

The fifth and last message lasted 50 seconds, and it consisted in her daughter saying some final words to her mom and started commenting about the longevity of P2. The message was longer but P2 started talking over the recording, and it was stopped by the researcher to hear what she wanted to say. She said "I was small, and... I went after I got married... oh... and she did too... and we... agreed to... he... old... he had very... we go to church dinners...haha (laughs), nuns were good".

MATADOC After ASPT

Baseline Responses

Pre-observational	**Post-observational**
Mouth tremor	Mouth tremor
Hands held together with a slow movement of arms back and forward	Holds doll with one or two hands
Eyes tracking	Head to center
Grabs strap with the right hand	Head rotation to R
Holds and caresses doll with the left hand	Manipulates doll sits it on her lap, adjusts its clothes, taps gently its body. This includes hand-eye coordination, bilateral integration, and finger dexterity
Head rotation to R, C, L, down	
Manipulates strap with both hands	

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus on more than 1 visual stimuli. Looks at instruments presented an assessor alternatively. Same as the baseline.

Responses to auditory stimuli. Inconsistent head movement towards instrument/assessor. Turned her head once to the voice of the assessor when he called her name. Responded consistently to the question "do you hear the sound?". Same as the baseline.

Awareness of musical stimuli. Showed consistent interactive responses within musical exchange. In one task, she played egg shakers and stopped 4 every time the assessor stopped while playing the song "When Irish Eyes Are Smiling", she also closely matched the tempo. Same as the baseline.

Responses to verbal commands. Consistently followed verbal commands. Followed the commands "play the drum", "shake the shaker", and "shake it high". She needed visual cues, and tactile priming to play the drum. Same as the baseline.

Arousal. Aroused throughout the session. Completely awake during the session. Same as the baseline.

Diagnostic Outcome. Score 9. Higher-level state.

Section 2: Essential Categories Principles Subscale

Changes in facial gesture through smiling during the chorus of KKK Katy, as a response to the melody. Eye direction movement during keyboard playing looking to her hand and the assessor when he introduced silences, as a response to rhythm, melody, and form. Changes in physical movements through finger dexterity and arm movement during keyboard playing and egg shaking, as a response to rhythm, melody, and form. She stopped playing silences included in the song "When Irish Eyes Are Smiling", as a response to form. Same as the baseline.

Section 3: Essential Categories Principles Subscale

In vocalization, she showed vocal sounds unrelated to musical stimuli. She did not fill the blank in at least 8 opportunities throughout the session. She did respond to verbal questions and initiated conversation too. Different from baseline.

In non-verbal communication, she showed consistent use of spontaneous and appropriate social communication gestures. She used head nodding, interactive eye contact during music playing, and hand gestures to reinforce verbal communication or as communication, like when she pointed to the piano to show her choice. Same as the baseline.

In choice-making, she communicated a preference between 2 objects. She pointed at the piano when asked what you like the piano or the guitar. Same as the baseline.

In motor skills, she showed spontaneous purposeful independent movement. She played the keyboard with her right hand and shook an egg shaker moving her right arm. Same as the baseline.

In attention to task, she attended to the entire session. The session lasted 41 minutes. Same as the baseline.

In intentional behavior, her responses were evident with goals achieved, like when she followed all verbal commands like playing the drum, shook the egg shakers, and played the keyboard. Same as the baseline.

In emotional responses, she showed changes in expressive behaviors related to stimuli on more than 1 occasion. She smiled after the chorus of KKK Katy started, and when she was validated by the assessor for her playing during "When Irish Eyes Are Smiling".

Stimuli 3 - LMT

When the researcher took out the guitar, as usual, she commented about her own and said, "I have my, still have... my... uhm... my..." and pointed to the guitar. The researcher tapped repeatedly his guitar while looking at her asking, she nodded yes and he said, "A guitar?" and she said "Yeah". Then he asked "What color is it?", she thought about the answer, so he gave her options, "Was it green?", and she said "Oh no, was like that" pointing and his guitar, and he continued "was it brown?", "yeah," she said.

The first application lasted 3 minutes and 55 seconds, and the goal was to increase her autobiographic memory. To start the session the researcher told her "I am going to play a song that someone very special used to play for you", she smiled with eyes and mouth wide open and said, "oh really?!". She listened to the song sustaining eye contact with the researcher. He left two seconds of silence between the first and the second verse where she nodded, smiled and laughed. Then, in the space of silence after the second verse, and before the chorus, she said "Who was Katie all right?" connecting this from the lyrics that she just heard that said "stuttering his song to KKK Kate". The researcher asked back "Who was Katie?" and she answered smiling "My sister", he said back "Your sister?" and continued singing the chorus. He left a space for her to fill in the last word of the chorus and she smiled and said "Katie". He repeated the chorus and left a space for her to fill in with the word "Katie", but she only nodded her head and said "yeah". When the chorus was over the researcher closed the song, and she said "Yeah, we had a... Kate since... Elizabeth...", and he said back "So you used to have a Kate?", and she said, "Oh [word], Katie, that's my har...and it that. Because that was my grandmother's name". As the researcher already knew that it was a common name on her family, he asked her "Wasn't your mother too?", and she said "Yeah", and he continued "Didn't you have a sister? Katherine? Katy" and she said "Katherine, my sister", and he continued "and your daughter?" and she said "no, she did not have any kids", so he got closer to her right ear and said louder "what's the name of your daughter?" and she said "Katy". Then, he said, "Everybody is Katy" and she smiled and laughed and said

"And my... hand lady.... there's.... ver... [unintelligible words] we go... they are all Katy, they are Irish".

The second application lasted 4 minutes and 48 seconds, and the objective was to increase social interaction, non-verbal communication, upper extremity control, and musical awareness through musical interaction. P2 asked "What are you going to play tonight?, and he said "I'm going to play some Irish songs", she said "Oh, my mother is very", and he said "That makes you Irish too" and she immediately said "oh yeah", and continued saying louP4y "I'm Irish [unintelligible word] all of them". Then, he gave her a piece of paper for her to read asking her "Can you read this?" and she said "When Irish Eyes Are Smiling", he asked "Do you know that song?" and she said, "Oh yes". He put a shaker in her hand and said, "You will play with me", he started strumming a 3/4 rhythm with the guitar, and told her "play with me, shake it". She nodded her head in agreement, and shook fast first, but when he started singing, she changed the rhythm to something slower and closer to what the researcher was playing on the guitar. She kept playing for 12 measures and then started coughing, the researcher stopped the guitar and waited for her to stop and asked her "are you ok?" she said "yeah" but kept coughing more. The researcher offered her a cup of water and she sipped in with a straw. When she finished, she said "all right", but then she took the shaker to her mouth and was about to sip in, like with the water. The researcher stopped her saying "not to the mouth, shake it". She furrowed her eyebrows, said "yeah", and started shaking it fast, like realizing her mistake. The researcher continued playing the rest of the song and she continued playing fast and out of the beat. When the song ended, he stopped the music altogether and she stopped too, with a delay of less than a second. After a pause of 2 seconds, he played the song all over again and she started playing with a more appropriate rhythm close to eight notes. He played 8 measures and stopped again for another two seconds, which she followed stopping also with a slight delay of one second. This procedure, of starting and stopping after 8 measures, was repeated until the song was over, and she followed on every occasion. The third time, in the pause she asked, "Can you play When Irish Eyes?", and the researcher said "yes" and continued with the last phrase until the end. He finished with a ritardando that she followed, and he cued a space for her to fill in the last word, but she did not sing. However, she did play the shaker matching the last chords of the guitar. The researcher smiled and applauded her, and she smiled back. He asked her "So you know this song? When Iris Eyes Are Smiling?" and she said "Yes... I haven't used it".

The third application lasted 4 minutes and 4 seconds and the objective was to increase the vocalization of target words through reading. The researcher gave her the lyrics of the song "Oh Danny Boy" and told her "read with me". She read with a certain difficulty, slowly, word by word, and with the assistance of the researcher, they reviewed most of the words from the first verse. He asked her, "do you know this song?" and she answered "no". Then, he started singing the verse, and she spontaneously joined singing, smiling like she had recognized the song. She followed the same rhythm making variations of the pitch as if she was singing, although, for the quality of her voice, it was closer to speaking. When they got to the chorus, she said "I need glasses", however, her glasses were not found in the room, and there was no information that she used glasses. The researcher continued singing the chorus, but she did not and kept looking at the lyrics. She did sing the last words that said, "I love you", saying a different word for the very last word "so". He asked her "Do you know this song?", and she said, "oh yeah, I... played... such... much".

The fourth application lasted 3 minutes and 55 seconds and the objective was to increase the vocalization of target words by retrieving lexical memory from a well-known song. The researcher sang the chorus of the song *"My Wild Irish Rose"* accompanied by the guitar once, leaving blank spaces for her to fill in with the words, which she did not. When he finished, she said, "I don't know that never heard it". The researcher took his guitar out, got close to her left side, and sang the song a capella while showing her the score and pointing the melody with his finger. He sang the song again and she nodded no but kept tracking the melody that the researcher was pointing and nodded her head yes when the melody was over. Then, he sang it a third time, but this time she spontaneously joined him singing the word “rose” and smiled. She then, filled-in the blank that he left for her, saying the word "grows", and she finished joining him in singing on the last words that said, "the bloom from my wild Irish rose". The researcher asked her, "So you know that one?" and she said "I used to", he continued asking "when did you use to?", and she said "oh, a long time... ten years ago" and laughed.

The fifth application lasted 5 minutes and 22 seconds, and the objective was to reminisce memories from her life related to her favorite things. The researcher told P2 that he was going to play a song from a movie that she used to enjoy. He sang "My favorite things" accompanied by the guitar. He played the first verse and made a pause, in the pause she spoke and said: "Never heard it". For that reason, he took out the guitar, got close to her left side, and sang the song a capella while showing her the lyrics on a paper. He sang the first verse again, but she again nodded and said: "never found it". He made her read the title with him, and she filled-in the last word "things". He immediately asked her "what is your favorite thing in your life?", she was about to answer and started coughing, but as soon as she stopped she said to him "Irish Rose", and continued "My mother and my father were Ros... Irish... but my grandfather died... pretty... so... my mother didn't rise again". The researcher said to her "That was surely hard for your mother... now, can you think about another favorite thing. What about your horses...?", and she emphatically said "Yeah!". He continued asking her "and what about trail rides?", she furrowed her eyebrow and seemed to be doubting about the question, so the researcher got closer to her left ear and asked the question again, this time louder. She said "Yes" and continued "We had made...ahh... braid ride (sic)... and... aah....". He supported her memory asking her a fact related to the memory, so he added "with Genie?", she smiled and repeated "Genie", and continued saying "and... another thing, my... sick... Katherine... she married a guy, and my dad ahead... won... can...and they decided to get more... pairs... and they did.... and I lived it out there".

The sixth application lasted 3 minutes and 42 seconds, and the objective was to reminisce memories related to the railroad and to retrieve lexical memory and semantic memory through a well-known song. The researcher held the hands of P2 and swayed her arms gently to the sides on a steady tempo. Over that tempo, he started singing the melody of *"I've Been Working on The Railroad"* with a single syllable "La". After 4 measures she spontaneously followed him singing the melody, for the first time, with a clear change of intonation. They sang 4 measures more and then the researcher started the song again, but this time with the lyrics. She followed singing with a clearer and louder voice most of the words of the first verse and half of the second verse. The researcher reduced the tempo as he felt that her rate of speech was slower, with this change her rhythm of singing was more accurate and she sang most of the words from the third and fourth verse. The researcher stopped the song after the fourth verse and with the ending pause, she laughed louP4y. The researcher immediately asked her "Who used to work in the railroad?" and she answered "My brothers", then he asked "What about your husband?", and she said "Oh, he worked [something] and my daughter did too", he followed-up saying "I think your husband did work on the railroad, right?", and she said "Yeah... he is still working! On Chicago. And my dad works on it, and my brother... ". The researcher validated her statements repeating them back to her, and then told that they were going to take a short rest before continuing.

MATADOC After LMT

Baseline Responses

Pre-observational	Post-observational
Mouth tremor	Mouth tremor
Head to C and R	Hands held together slowly moving forward and back
A small movement of feet	Trunk forward/back
Eyes tracking	Small feet movement
Left hand small movement caressing doll	Head to C, R
Left hand touches the face	Eyes tracking
Hands together on lap	Manipulates strap with both hands
Manipulated doll with both hands	

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. She could focus alternatively in more than 1 stimulus. She tracked a picture from "The Sound of Music" twice in all 4 quadrants. The stimulus was presented with 2 to 1 feet distance. She used one prompt to keep her tracking. She looked at the assessor and the instruments alternatively. Same as the baseline.

Responses to auditory stimuli. She showed inconsistent turning towards stimuli. She tracked the music presented to her midline. She responded turning her head to her left in 2 out of 4 using the A3 and D#6 tones bells, and only with verbal commands. Same as the baseline.

Awareness of musical stimuli. She showed consistent interactive responses within musical exchange. She played the drum to the song *"I've Been Working on The Railroad",* while the assessor sang and played guitar. She followed several musical changes like starting, tempo changes, silences, ritardando, and ending. Same as the baseline.

Responses to verbal commands. Consistently followed the verbal command. She followed three different commands using the tambourine "shake it", "shake it high", and "shake it low". Same as the baseline.

Arousal. She stayed aroused throughout the session. She kept awake and engaged. Same as the baseline.

Diagnostic Outcome. Score 9, Higher-level state.

Section 2: Essential Categories Principles Subscale

She showed changes in face gesture through smiles after drum playing, as a response to rhythm, melody, and form. Eye movement changes through hand-eye coordination while playing the drum or when looking at music played by the assessor as a response to rhythm. Physical movements changes when playing the drum with the assessor and shaking the tambourine in response to rhythm, melody, form, and verbal commands. Changes in vocalization once through humming at the end of "When Irish Eyes Are Smiling" as a response to the melody. She tracked the high tone bell as a response to pitch. When playing she followed cues of silences as a response to form and she followed the ritardando played by the assessor as a response to tempo. Same as the baseline.

Section 3: Essential Categories Principles Subscale

Vocalization responses showed inconsistent vocal sounds to musical stimuli. She hummed for 2 seconds at the end of the song "When Irish Eyes Are Smiling" and she responded verbally to questions. Like baseline.

Non-verbal communication showed consistent use of spontaneous and appropriate social communication gestures. She pointed with her hand to the instrument of her preference on two occasions, she nodded her head to say yes, showed interactive eye contact during instrument playing, and waver her hand to say goodbye. Same as the baseline.

Choice-making responses showed communication of preference between 2 objects. She pointed her preference on two occasions, preferring guitar over tambourine, and the drum over the guitar.

Motor skills responses showed spontaneous and purposeful independent movement. She played the drum by holding it with one hand and the mallet with the other and shook the tambourine with two hands. Same as the baseline.

Attention to task responses showed attention for the entire session. She participated actively and engaged in the 16 minutes of session, which included initial song (1'), visual tracking (1'40"), auditory tracking (2'54"), verbal commands (40"), choice-making (38"), song with drum playing (3'23"), and goodbye song (30"). Same as the baseline.

Intentional behavior showed intentional response evident with goals achieved. She played the drum, tambourine, stated her preference pointing with her finger, and waved goodbye. Same as the baseline.

Emotional responses showed changes in expressive behaviors related to stimuli on more than 1 occasion. She smiled after drum playing and after goodbye song. Same as the baseline.

APPENDIX D: MATADOC BASELINE REPORT, NARRATIVE OF CONDITIONS, AND MATADOC POST-TEST REPORTS FOR P3

MATADOC Baseline Report

Observed Responses at Rest

During the pre- and post-behavioral observation periods of each assessment session P3 demonstrated several positive behaviors. All the pre observational parts for all 4 sessions and the post observational part from session 1 were done with no stimulation. While during the post observational parts of sessions 2, 3 and 4, her wife tended to interact verbally with him and the assessor, especially in sessions 2 and 4 with a greater number of verbalizations from her part. Nevertheless, these interactions were helpful to know his responses during typical verbal interactions.

He showed a range of different behaviors such as movements of the head in different directions and tracking movement with his eyes. He usually looked outside through the window, but switched to the right, sometimes looking at the assessor, or switched to look to the front, or at his hands. It was common to see switching movements of arms and hands (touching/rubbing hands and fingers, hands on his laps, rubbing pants, holding the seat of the chair, touching nose/head/neck, elbows over his laps, hands together), trunk (forward and back), and lower extremities (legs to the front, and crossing one leg over the other).

He initiated a conversation with the assessor, the caregiver, or his wife, and answered to questions made by them. In the first session, he initiated a conversation with the assessor and reminisced about the place he was born and the time he was in the air force. During the verbal interactions in the post observational part, he showed an ability to refer to the session, like mentioning that there was singing involved, that the assessor sang, and he could recall the instruments involved in the session sometimes with no assistance at all.

Musical behaviors were also observed during both pre and post observational periods. These behaviors were clapping, tapping the chair or lap with hands or fingers (which sounded like drumming for the clear rhythmic component), singing simple short motifs usually with syllables like "doo" and "dee", and only once a rhyme beginning with "eeny meeny miny moe". These behaviors appeared to be more frequent during the post observational periods than the pre observational periods, if considered only sessions 1 and 3. Because in sessions 2 and 4 other variables appeared, where her wife talked throughout the observation period, altering his attention and responses. At the same time, his musical behaviors could be connected to an elevated mood, as in session 3, he was showing a dull face expression, her wife verbally stated his bad mood, and only one of the behaviors appeared. While in the post observational period he showed 4 different musical behaviors.

Session 1

Pre-observational	**Post-observational**
Hands together	Clapping
Head to L, R, ML	Head to L, R, ML, and up.
Talks to the assessor (1)	Scratches neck/head
Hand gestures while talking to reinforce verbal communication	Taps chair/lap with hand/fingers
Restless arms/hand movements: adjusting pants, touches/rubs hands/fingers, touches the chair, and switches positions.	Restless arms/hands movements: touches/rubs hands, adjusting pants, and rubs legs
Laughs	Hands together
Taps laps	Leg movement to the front
Trunk forward/ back	Trunk forward/back
Crosses left leg over right	Elbows on laps
	Talks: to the caregiver (2) and the assessor (3)
	Laughs
	Sings "doo ree doo ree doo"

1) P3 asked, "Do you know where Potosi Missouri is?" The assessor answered "no", and he continued "´Cause that's where I was born, and I lived there until I got into the air force [UWs] in Missouri. They said, you have to go into the air force. So, it was good. I would go and do a month [UWs] and they'd send up to another place". The assessor followed-up: "Where did they send you?", and he answered "Let me think...way up north, let me see...Bassol (sic) people. Bassols (sic). They were the boys there. But I would down south a little bit more. Later on, I met all the Basque boys, and we had a lot of fun (laughs)." The assessor asked him: "Were those good times?", and he answered "Yeah. Good times. Yeahp". In a second intervention, he initiated conversation again and said, "I love all this [UWs] different people that comes in staying, and sings for you" (smiled)

2) P3 said to her caregiver: "It's your time", and she asked back "my time for what?", and he said, "It's your time to sing" (laughs). She said, "Oh no, I can't sing", and he continued " Sure, if this gentleman here can, then you can".

3) P3 said to the assessor "they like that", at least 45 seconds after talking to the caregiver.

Session 2

Pre-observational	**Post-observational**
Clapping	Talks/answers to his wife (4)
Head to L, R, ML	Head to R, keeps eye contact with wife and assessor
Taps chair	Touches/rubs his fingers/hands
The left hand touches his face	Adjusting pants and shirt
Sings "doo dee doo"	Taps his laps
Checks watch	Leg movement to the front
Arms/hand movements: rubs hands/fingers, touching the chair	
Hands together	
Hands on his laps	
Left leg to the front	

4) P3 said to his wife "You missed it all!", and she asked him "What did you do?", but he got distracted with a fly so she asked him again, and he answered, "We were singing". She asked back "You?", he answered, "this guy" (pointing at the assessor), she said, "He's a musician" and he said "Yeah. Right". She asked, "Did you know all the songs?" and he answered "yeah".

In a second intervention she asked him: "Was he playing guitar or not?", and he answered "Yeah", and she asked back "Did you play?", and he answered, "No, I sit here and I watched him playing". Then the assessor asked him "Did you play anything today?", he answered "no", the assessor insisted "Are you sure?", and he said "no". The assessor asked, "Did you shake?" and he answered "Oh! yeah" (moving his hand like shaking a shaker), the assessor continued "And you played drum too", and he said "yeah". His wife said, "I've never seen you playing anything" and he said back to her "Well, there's a first time for everything". Lastly, the wife asked P3 "Did you play this? (showing the tambourine), and he said "No", then she asked him "Did you play the drum?" and he said, "Yeah, a little bit". The assessor asked him "Did we play the piano?" and he said "No, I don't think so", the assessor continued "No, we didn't, did we play guitar?" and he answered "yeah", the assessor asked "Who did?" and he answered "I don't know" (pointing to the chair where the assessor was). The assessor asked, "Do you think it was me?" and he said, "Yeah I think it was you".

Session 3

Pre-observational	**Post-observational**
Head to L, R, ML	Answers to his wife (5)
Hands together	Taps chair/lap
The right hand holds back of the chair	Sings "doo dee doo"
Touching/rubbing hands/fingers	Head to L, R
Taps chair	Tongue slaps
Restless right-hand fingers movement tapping back of the chair	Clapping
	Touching/rubbing hands/fingers/laps

5) The wife said to P3 "That's what the doctors are gonna be using... music, music to cure the problems. Don't you feel good with the music?" and he said "Yeah".

Session 4

Pre-observational	**Post-observational**
Hands together	Taps the table
Head to R, ML, L	Head to R, ML, L
Left hand to head/nose	Explores/manipulates tambourine
Left leg to the front	Sings "doo dee doo"
Clapping	Leg movement to the front
Trunk forward/trunk back	Adjust glasses
Sings a rhyme with "eeny meeny miny moe" and "dee dee dee dee"	Hand to mouth/face
Rubbing/touching hands/fingers	Touches/rubs hands/fingers
Taps chair/laps	Taps lap
Hands adjusting shirt and rubs pants	Straightens pants
Talks to caregiver: "beautiful flowers"	Scratches arm
	Answers to his wife*

* The wife talked to the assessor throughout the observation period. In the end, she asked P3 about who taught him to play, and he said "myself".

MATADOC Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Pictures of significant instruments and well-known musical artists were used as stimuli: pictures from Elvis Presley, a violin, and Johnny Cash. These stimuli were presented at approximately 1 to 2 feet from his eyes. In all the 4 sessions he consistently followed the stimuli on the 4 quadrants (Left, Right, Up, and Down). To keep him engaged in tracking a simple prompt of "keep looking" was enough or asking a question about the picture. During other tasks, he was able to shift his eye direction between two different stimuli, like during choice-making by looking at two different instruments that were presented, or during instrument playing by looking at the instrument and the assessor. Therefore, his visual responses categorized for the higher level stating that he could focus alternatively on more than 1 visual stimulus.

Responses to auditory stimuli. Guitar playing and singing were presented in P3's midline. During this task he kept consistent eye contact with the assessor, and being actively animated by the music: singing, moving to the music, clapping, tapping, nodding his head to the beat. During a second task of tracking auditory stimuli, two hand chimes were used A3 and D#6. The stimuli were presented close to the ear with a soft volume and outside of her visual field. Some few times he started clapping or singing "doo dee doo" when the sound appeared. He consistently turned his head toward the stimuli, or pointed with his hand, localizing it with 100% accuracy.

Awareness of the musical stimuli. P3 showed consistent interactive responses within musical exchange throughout the 4 sessions. He got extremely animated with music, and the behaviors observed when a song was played were the following: head nodding to the beat, tongue slaps, clapping, tapping with his hand on his lap or chest, waving of hands and arms, playing an imaginary guitar, smiling, and singing. His musicality was not accurate, which means his rhythm sometimes was on the beat, but other times was out if it, his singing was very mumbled, and many times he did not follow the melody.

However, when the task was to play a song or improvise with an instrument like keyboard, egg shakers, tambourine, drums, or even with clapping he followed turns, starting/stopping, ritardando, tempo changes, and dynamics, which showed high level of awareness of the music being played, despite his low musical skills.

Response to verbal commands. P3 responded consistently to verbal commands in all 4 sessions. He followed the following commands "touch the drum", "hold the drum", "shake the tambourine", "shake it high", "shake it low", "shake it fast", "shake it slow", "play soft", and "play loud".

Arousal. P3 stayed aroused throughout the sessions in all 4 assessments. He was awake and actively engaged in all tasks presented, being increasingly animated during song presentation and music playing.

Diagnostic Outcome. P3's scores were congruent with the presentation of someone in Higher-Level State. In the 'Essential Categories Principle Subscale' over the four MATADOC assessment sessions in the response categories (visual, auditory, awareness of musical stimuli, verbal commands, and arousal) P3's total scores were: Session one 10 (Higher-level state), Session two 10 (Higher-level state), Session three 10 (Higher-level state), Session four 10 (Higher-level state)

MATADOC Section 2: Behavioral Responses to Music

P3 showed several positive responses to music. Changes in facial gestures like smiling at the beginning, during, and after musical tasks, especially after instrument playing, which could be related to rhythm and melody. Changes in eye contact were observed during song presentation and instrument playing where he sustained eye contact with the assessor and alternated it with his instrument, especially during alternate turns task, which could be related to rhythm and form. Changes in physical movement were observed during song presentation and instrument playing when he played drums, keyboard, tambourine, and egg shakers, or when he clapped, slapped his tongue, tapped his lap with his hand, and waved hands and arms to the music, this was as a response to rhythm, dynamics, tempo, and form. With instruments, he matched dynamics and tempo changes (slow, fast, ritardando), copied rhythms and created his own, and followed the general form of starting and stopping with the assessor. Although he responded to form by stopping with the assessor, it was observed that he did not always get the endings of songs, by his physical disposition to continue and the fact that he initiated playing on his own, it was clear that endings were not always followed. Nevertheless, he stopped playing completely after no more than 5 seconds. Changes in vocalization were observed through laughs at the end of the instrument playing as a response to form and achievement. He sang some specific cued words during song presentation as a response to melody and form. However, most of his vocalizations were mumbled and started when the assessor started singing, therefore a response to rhythm, melody, and timbre of the voice. He also sang improvising short melodies in between phrases with simple syllables like "dee dee dee" or "doo dee doo", as a response to form. Additionally, on two occasions he sang these improvised melodies during the auditory tracking task, after listening to a tone bell most probably as a response to pitch or timbre, however, this was not consistent. Another response to timbre was observed once when he shook the shaker to his ear and said with surprise "oh". Although P3 did not show a deficit in maintaining wakefulness states, changes in increased arousal could be identified every time he responded to music by either singing, tapping, drumming, laughing, playing, creating, and commenting on the music presented.

MATADOC Section 3: Clinical Information to Inform Goal Setting and Clinical Care

All the areas covered in this section were rated as strengths for P3, except for motor skills that were rated as a developing area, but this being the highest possible level of the assessment.

Vocalization responses were ranged between attempting to sing words and singing the last word/phrase that acted as the cue. However, he did not respond to every cue and was able to retrieve only some of the words. He mumbled most of the words of songs or used the syllables "doo" and "dee", sometimes following the melody, but sometimes not, he sometimes matched the pitch of the assessor and other times sung a 4th or 5th below, most of the time he copied the vowels of the words that the assessor was singing, sometimes the rhythm, and in between phrases he continued singing by using improvised short melodies with syllables like "doo" or "dee". If cued in the right place he would correctly sing some specific words, usually matching the name of a song or at the end of a phrase. For example, he only sang correctly: the words "working on the railroad, all" on "I've Been Working On The Railroad"; the words "with you" in "Can't Help Falling In Love"; the word "night" in "Strangers In The Night"; the words Jack, no more, no more" in "Hit The Road Jack", the words "on my mind" in "Georgia On My Mind", or the word "game" at the end of "Take Me Out To The Ball Game", or the words "America, my home sweet home" in "God Bless America". His vocalization was rhythmically much more inaccurate with fast music than slow.

Non-verbal communication was rated high as he showed consistent use of spontaneous and appropriate social communication gestures. His responses included head nodding to show understanding, interactive eye-contact during turn-taking, hand gestures to reinforce verbal communication or direct communication like pointing his choice, also he followed and initiated a high five after a musical task like song presentation or instrument playing.

In choice-making, he communicated his preference between two objects in all 4 sessions. In two sessions he was asked if he preferred guitar or drum and very time, he said guitar, although once said "drum" but looked at the guitar, and with some assistance, he corrected the word on his own. Only once he gave a reason for his choice and said: "because the sound is more flexible to the people". In session three it was asked to state his preference between drum and tambourine, and he picked the drum twice, even after shifting them to the other hands. As he was showing good responses questions without objects were asked. When asked if he preferred slow or fast music, he said he preferred fast music, and at the end of the session it was asked if he wanted to continue or stop and he said: "continue a little more".

Motor skills were scored high as showing spontaneous purposeful independent movement. He showed responses in upper extremity when clapping, tapping his lap, and playing tambourine (tapping it against hand and lap, and by shaking it), drums (with finger and mallet), shaking egg shakers, and keyboard using alternatively both hands and several fingers. These movements did not require any facilitation.

Attention to task was rated high as he actively attended the entire session. Each session lasted between 27 and 33 minutes, and the tasks were usually: initial song, visual tracking, auditory tracking, verbal commands, choice-making, song presentation, instrument playing, and closing song.

Intentional behavior was rated high as he showed intentional response evident with goals achieved. This was observed in the way he improvised with the keyboard creating melodies and interacting with the assessor, when he sang specific words of the lyrics of the songs presented to him, or when he played the drum exploring different parts of the head or shook the shakers or tambourine following closely the beat of the music.

Emotional responses were frequent, contingent to stimuli, and observed on more than one occasion. These responses included smiling, laughing, verbal comments, and were usually observed at the end of songs or instrument playing. He usually said "outstanding", "I love it", "I feel great, I feel like a king", and with one of his favorite songs "Georgia On My Mind", he said, "That's beautiful". A dramatic change of mood was seen in session 3 where he started with a negative mood evidenced by his facial expression (furrowed eyebrow, corners of the mouth downwards), lack of verbal interaction, and reports of her wife, but finished the session smiling, laughing, and singing.

Relations Between MATADOC, the GDS, and the CDR

P3 was assessed using the CDR scale by the Student Music Therapist, where he scored a 2, meaning moderate dementia. He rated moderate in areas of memory, community affairs, home and hobbies, and personal care. This means that he presented severe memory loss where only highly learned material was retained, and new material rapidly lost; appeared well enough to be taken to functions outside a family home, with no pretense of independent functions outside a family home; only simple chores preserved, very restricted interests, and poorly maintained; and required assistance in dressing, hygiene, keeping of personal effects. He rated severe in orientation, and judgment and problem solving, which meant oriented to person only, and unable to make a judgment or solve problems.

Using the GDS he scored a 5, meaning the moderate level of dementia and moderately severe cognitive decline. However, as this is a rough definition, some pieces did not fit him. For example, he remembered the names of her spouse, siblings, and grandchildren; he was disoriented to time and place, and he required some assistance in toileting and few times eating.

As MATADOC results showed a high level of awareness of his environment, his cognitive deficits should be addressed to other areas such as memory, orientation, executive functioning, speech, and information processing, but not affecting his ability to be aware of his surroundings. Additionally, his multiple positive behavioral and mood responses to music make him a candidate for a diagnosis of acquired musicophilia. The fact that this condition has been reported to be more present in FTD than AD, and due to lack of language during verbal musical tasks like singing, it provides support to an alternative diagnosis of Semantic Dementia.

Results and Recommendations of the MATADOC Assessment

MATADOC outcomes indicate that P3 was consistently responding at a Higher-Level State of awareness. He demonstrated awareness of himself and his environment achieving the highest score in all assessed items, except for vocalization, where despite being verbal, he showed a low number of words verbalized during song singing.

Comparing the pre-observational with the post-observational periods a trend to produce more musical behaviors were observed in the post-observational part in sessions 1 and 3. While sessions 2 and 4 were not performed with him at rest, as his wife intervened talking with the assessor and P3, affecting his attention and responses. At the same time, the musical behaviors observed could be, on one hand, an effect of the musical stimulation provided during the protocol, but also it could be a sign of elevated mood, especially considering the dramatic change of affect in session 3.

During the assessment he showed consistent and high ability to visually track more than one stimulus presented at the same time, to correctly track auditory stimuli, to respond interactively within a musical exchange and especially when playing instruments, high response to verbal commands and high arousal. He showed responses to different elements of music like melody, rhythm, dynamics, timbre, form, and tempo. These elements of music produced behavioral responses in his face expression like smiling, maintaining and switching eye contact, singing mumbled words, filling-in few specific words in a song, improvise melodies using his voice with simple syllables, and move purposefully upper extremities to make music. He showed ability to recall some words of well-known songs; high use of non-verbal communication through hand gestures, head nodding, and interactive eye contact; ability to make choices between two objects; purposeful movement of upper extremities in musical tasks like instrument playing; high attention to musical tasks, intentional behaviors like singing and playing music; and emotional responses through smiling, laughing, and verbal comments of music liking.

In conclusion, P3 did not show deficits in awareness, and his cognitive deficits should be addressed to other areas most probably to as memory, orientation, executive functioning, speech, and information processing. His high response in a musical context suggests that music therapy is highly recommended to work on maintaining his cognitive, spiritual, emotional, physical, and social areas. Noteworthy is the effect of music stimulation to improve his mood, especially through an active application such as improvisation and music playing. Additionally, including his spouse to further connect with him could be highly beneficial too to improve his quality of life and from his loved ones.

Stimuli 1 - LMT

The first application lasted 3 minutes and 30 seconds and the objective was to increase the verbalization of target words through singing a well-known song and the use of rhythmic, tactile cues, and melodic priming. The researcher held the hands of P3 and waved them from side to side achieving a moderate tempo (100 bpm). Then the researcher started singing *"I've Been Working On The Railroad"* with a single syllable "la". P3 spontaneously followed singing with the same syllable, similar contour, the equal rhythm of the song, and not in tune by singing approximately a 4th below. They sang together the first 16 measures and then the researcher started all over again, this time adding the lyrics. P3 followed mumbling the lyrics, singing "da dee da" or similar syllables, and correctly said the words "on the railroad", "all". "day", and "blow". They sang together the same 16 measures. When they finished the researcher clapped and P3 too, and he said smiling "very good!". The researcher said, "Now try with me", and he clapped the same tempo, and continued singing the song. P3 spontaneously started singing mumbling words and tapped his laps to the same tempo. No words were correctly said this time. The researcher prompted said "all right" and prompted him a high ten with both hands, which he followed smiling.

The second application lasted 13 minutes with 13 seconds and the objective was to increase the verbalization of target words through reading, and train short-term memory through a recall of learned words. The researcher offered P3 two songs and he had to pick one. The researcher gave him the pages to read the titles "Can't Help Falling in Love" from Elvis Presley and "Georgia On My Mind" from Ray Charles. After he read the researcher put both pages in front of him and asked him "Which one do you want?", and he looked at the one from Elvis and said, "What about Elvis Presley?". The researcher said to him that they will be starting by reading the lyrics. He took out the lyrics that were printed with big letters and pointed each word and P3 started reading, word by word, first slow and progressively started connecting more words. He read all the words correctly from the verse and the chorus with minor corrections from the researcher. Then, the researcher asked him to listen to him singing, and he sang the first verse, P3 started singing as well, and the researcher stopped to redirect him, he repeated the command to listen and not sing. The next time, he only listened, and the researcher sang the first 8 measures. The researcher asked him to read and sing with him. P3 followed singing reading correctly the 8 measures and continued singing the next 8 measures with 100% accuracy regarding correct words. His singing was out of tune, but both rhythm and contour were correct. The researcher validated his achievement with a high five, which he followed, and he smiled and laughed. The researcher presented him with a new page with the next verse. The researcher started singing and P3 followed singing and reading, again with an accuracy of words of 100% correctly verbalized. The researcher congratulated again with a high five and he said: "thank you". The researcher continued with the chorus and the following verse, and he performed with the same high accuracy of verbalized words. Then, the researcher handed the first page to him and took out the guitar, he started playing the chords and he started to sing. P3 spontaneously followed singing, but he did not wait between the spaces, and the researcher had to redirect him saying "wait, wait go slow". He followed better, matching pitch and melodically in tune, but some few words were incorrectly articulated. In the first verse, he correctly verbalized a total of 13 out of 16 words. In the second verse, he correctly verbalized 11 out of 17, mainly because he omitted the initial consonant. When he started singing the chorus, he omitted all the first lines, then the researcher stopped playing and asked him to read it again without music. He did and then he tried with music, the words correctly verbalized but his singing was inaccurate rhythmically and melodically. In the following verse, he started reading fast, and out of tempo, the researcher had to remind him that he had to do it slower, but he continued singing with his eyes looking at the lyrics. The researcher stopped the music and gave him the order to sing slow. They tried singing again and he verbalized correctly all the words, although he got lost at the end, and the researcher had to point him where they were singing. When they finished singing, the researcher took the lyric page from him and asked him "What song are we singing?" and he asked back "What was it?", and the researcher answered trying to cue it and said "Can't... Can't... help... falling in...". P3 did not complete the name, and the researcher said, "the next word starts with L", and he said "love". The researcher asked again, and he did not remember the name. The researcher said the name of the song again and the artist and told him that they were going to sing this time without reading. The researcher repeated the first word three times before starting. When he started singing P3 did too. He sang with more correct rhythm, sometimes copying the last vowel of each word, and improvised some parts of the melody with "doo dee doo", including spaces where no melody had to appear. He consistently sang correctly the words of the name of the song "in love with you". In the first verse, he verbalized correctly 9 out of 16 words. In the second verse, he verbalized correctly 9 out of 17 words. On the chorus, he only got 1 word correctly verbalized out of 17. In the last verse, he sang correctly 4 words out of 17.

The third application was the continuation of the second application and it lasted 11 minutes and 20 seconds. The objective was to increase verbalization of target words by reading words and using the song *"Georgia On My Mind"*. It consisted of the same procedure done with the previous song, which meant reading a song, sing it while reading it, and then sing it by rote memory. First, he read the whole song, word by word, with only two words, said incorrectly that were corrected by the researcher. Then, they sang a capella with the researcher pointing the words, he sang 100% words accurately. The researcher validated his accomplishment and he said: "thank you". Then, the researcher gave him the lyrics and he took the guitar. He asked him "What are we singing?", and he started reading the lyrics, and even though the researcher asked the question again he did not answer the question, but rather started reading through the papers with the lyrics. The researcher said the name of the song and started strumming the guitar. P3 started singing correctly, but on the second line he started singing with "doo dee doo". Noticing that his attention was not on the lyrics anymore, the research redirected him, pointing at the correct place of the lyrics, and then he sang correctly the rest of the words. For the most part, he tended to not wait on the spaces between phrases, singing over these spaces. In the first verse, he sang correctly 12 out of 16 words. In the second verse, he sang correctly 13 out of 16 words, and the researcher had to point the place of the lyrics twice. On the chorus, he sang correctly 20 words out of 21. In the last verse, he said correctly 10 words out of 16, with no assistance delivered. The researcher validated his accomplishment providing verbal positive reinforcement and shaking his hand.

To close both applications and to assess retrieval, the researcher asked P3. "Do you think we just sang Ray Charles?" he said "no". He continued asking "What about Elvis, did we sing Elvis?", and he said "no" too. Then the researcher showed him the page with the lyrics of *"Georgia On My Mind", and* made him read the title of the song, and he said, "oh! yes, yes, we did". The researcher gave him the lyrics of the song from "Can´t Help Falling in Love", and he said "no" again.

MATADOC After LMT

Baseline Responses

P3 showed similar responses at rest observed compared to the first MATADOC. Again, no musical behaviors were observed in the post-observational period as he was engaged looking at how her wife was looking for something on the cabinets throughout the period, consistent with his head looking only to his right.

Pre-observational	**Post-observational**
Scratches head	Hands grabbing sides of the chair
Hands together	Accommodates table with both hands
Head to R and L	Head to R
Touches/rubs hands/fingers	Scratches ear
Sings "doo dee doo"	Leg movement to the front
Taps lap	Elbow on the table holding his head
Leg movement to the front	Trunk forward/back
Hand to face/mouth	Shifting positions of the body and arms: one hand holding side of the chair and the other on the table, one elbow on the rim of the back of the chair and the other on the table, arms on the laps (listens to his wife that talks to him).
Talks/answers to assessor*	Accommodates glasses
Crosses one leg over the other	Hand/fingers movements on the table
Smiles	Rubbing hands/fingers
Moves feet	

Looks at watch	
Straightens pants with hands	
Movement of fingers on the chair	
Checks pockets	

* P3 said to assessor "goes fast", he answered "what goes fast?", and P3 said "the songs" and continued "when you know it, you have them, and when you go out, and it comes into your ears it's really better". The assessor asked him "What songs did you like?", he repeated the question and said "I don't know what it was", the assessor said "I'm going to give you a clue, one of the song was Can't help... (wait), Can't help falling..." and he completed "falling in love". The assessor said, "The other one was written by Ray Charles... (waits) and it starts with the name of a state that starts with G", he thought and answered "Georgia? On my mind", the assessor confirmed his answer, and he said, "I knew that one".

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus alternatively on more than 1 visual stimulus. He tracked the stimuli in all 4 quadrants. During choice-making and instrument playing, he looked at the assessor and instruments alternatively. Same as the baseline. Additionally, he retrieved the last name of the artist presented on the image by saying her first name "Dolly..." and he completed "Parton", however, he first said it was "Marilyn Monroe".

Responses to auditory stimuli. Consistent localized auditory stimuli played with hand chimes (A3 and D#6) in 16 opportunities. Same as the baseline.

Awareness of musical stimuli. Showed consistent interactive responses within musical exchange. During keyboard improvisation, he followed rhythm, tempo, dynamics, and ending. Same as the baseline. Trained songs were sung by him with more accurate rhythm and more words correct.

Responses to verbal commands. Consistently followed verbal commands. Same as the baseline. He followed the following commands "touch the drum", "shake the tambourine", and "touch the guitar ".

Arousal. Aroused throughout the protocol. Same as the baseline.

Diagnostic Outcome. Score 10, Higher-level state.

Section 2: Essential Categories Principles Subscale

Same as the baseline. Changes in facial gestures through smiles at the end of songs and during music playing as a response to rhythm, melody, and form. Changes in eye direction by maintaining eye contact during song presentation as a response to rhythm and melody, and switching eye direction during music playing, between looking at his hands playing keyboard and the assessor, especially when he stopped the music, as a response to form. Changes in the physical movement of upper extremities when he clapped, played drums, tambourine, and keyboard, accompanied by the assessor, as a response to rhythm. Head nodding to the beat as a response to tempo. Changes in vocalization, through singing songs as a response to the melody. Responses to dynamics and were observed during keyboard playing when he matched the volume and the tempo changes of the assessor´s music played with the guitar.

Section 3: Essential Categories Principles Subscale

Vocalization: He sang the last words of phrase/music that acted as a cue. Same as the baseline. However, a big change was observed compared to the baseline of the same songs "Can't Help Falling in Love", and "Georgia On My Mind". The rhythm of the voice was closer to the original song, he waited for more in between phrases avoiding filling in the spaces with improvised melodies, and overall more words were retrieved.

Non-verbal communication: Consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. He communicated using hand gestures to reinforce verbal communication and interactive eye contact during instrument playing.

Choice making: Looked toward more than 1 object presented simultaneously. Same as the baseline. He was asked if he preferred guitar or drum and he pointed at the guitar twice, with assistance saying the first syllable he retrieved the name of the instrument. To a second question if he preferred high or low sounds he answered "high".

Motor skills: Spontaneous purposeful independent movement. Same as the baseline. He improvised on the keyboard and shook the tambourine during the closing song, all with upper extremities.

Attention to task: Attended for the entire session. Same as the baseline. Participated actively during the 20 minutes of the session.

Intentional behavior: Intentional response evident with goals achieved. Same as the baseline. Improvised playing melodies on the keyboard, sung songs more accurately, and made consistent choices.

Emotional Response: Changes in expressive behaviors related to stimuli on 1 occasion. Same as the baseline. Smiled and laughed as usual at the end of each musical task. At the end of songs, he verbalized the words "outstanding" and "excellent", and "in my heart forever" at the end of the improvisation task.

Stimuli 2 - RS

Before the session started the researcher asked P3 "What do you think we are going to do today?" and he answered, "We are going to learn how to make music".

The session lasted 30 minutes and consisted in listening to music through headphones while he was seating on a chair The researcher was seated in front of him, and he provided a brief explanation to the patient before putting the headphones on, which he agreed by saying "ok" to each step of the procedure.

The first song was "Sweet Home Alabama" by Lynyrd Skynyrd. As soon as the song started, he looked at the researcher, gave a thumbs-up, and said "wonderful" while nodding his head to the beat. Then he said, "I've heard this one before" and smiled. He started singing with "da dee da dee", clapped with his hands, and produced tongue slaps. He looked at the assessor again and said "All right! Thank you" still smiling. He continued singing using simple syllables like "dai", "la", "bam", "boom", "doo", and "da", clapping, and moving his head. Both clapping and singing did not match the sound or rhythm of the song, but the claps and head-nodding were on the same tempo. Then he looked at his caregiver and said "Come on sweetheart" while moving his hand with the palm up and bringing fingers in and laughed. He continued saying "Is it beautiful!" and laughed loud and clapped, and then he said, "come on love, get it back here" and tapped his lap. He continued singing and clapping, but the melody he started mumbling resembled the ones that the military used when they exercise. Then he moved his whole trunk to the music and while still clapping he said: "I love those". He continued singing, clapping, smiling, and moving, and looked at the caregiver and said, "right here, in my heart" and touched his chest where his heart was. He continued singing tapping his chest, clapping, tongue slapping, singing, smiling, and moving his body. He repeated the 4-measures military melody and finished the fourth measure saying, "like the world it´ll be", he did it another time and this time finished saying "and we're having all like this". His clapping was loud, and many times matched what he was singing, but including much faster rhythms like sextuplets. He clapped one last time and said

"Excellent!". This last clap was four seconds after the song finished. The researcher asked, "Is it done?" and he said "yeah" and he took the phones off his head. The researcher asked him "Do you know that song?" and he turned his head down like trying to think. The researcher asked him "Was it *Georgia On My Mind*?" and he pointed at him and said "That's it!", the researcher continued and said "Or was it *Sweet Home Alabama*?" and said, "Oh no, that's for sure".

The second song was *"Walking After Midnight"* by Patsy Cline. When the song started he opened his eyes wide, moved his arms and head to the music, and sung and improvised melody with “da da dee daa day it is a wonderful sweetheart". He continued mumbling unarticulated words while tapping his chest with both hands. At 28 seconds he sang the words "after midnight" together with the song. This time the melody and phrases of his singing resembled the song, the tapping with his hands also matched the tempo of the music. He kept tapping his chest, nodding his head to the music, and when he was not singing, he produced slapping sounds with his tongue. He intermittently incorporated "doo dee doo" to his singing. He stopped singing and tapping his chest 40 seconds after the recording stopped. The researcher told him to take the headphones out, and he did. The researcher asked him "What did you just hear? Was it Ray Charles or was it Patsy Cline?" and he said "Patsy Cline", he continued asking "How old were you when you first listened to Patsy Cline?", P3 thought about the question and answered "I was 22 years old", which in fact could be true because the song was released when he was 19 years old. The researcher continued asking "What were you doing by then?" and he answered "I was just out, out in the country. There... then, when it goes for, old and the younger, and, it was it, there, yeah.". The researcher continued asking "Who else was there?" and he said, "It was so long ago, Elvis Presley I think it is, and Kevin Cline".

The third song was "Jailhouse Rock" by Elvis Presley. When the song started, he looked at the researcher and gave him a thumbs up. He then started clapping and singing unarticulated words, matching the phrases of the song, and continued doing this getting louder. Progressively the phrases he sang became more continuous and partially matched with the song. He said the word "rock" together with the music one minute after the song started, this was the only word he sang during the song. His singing matched the verse more than the chorus, and at the same time, this melody resembled the one he sung during the first song (the 4-measure melody that the military use when they exercise as seen in the movies). He repeateP4y clapped as soon as the song ended saying "outstanding!". P3 took the headphones out after a command given by the researcher. The researcher asked him "Who was singing?", P3 thought and as he was not answering the researcher gave him options, was it Ray Charles or...", he rapiP4y said "Ray Charles!", and the researcher continued "...or was it, Elvis Presley?", P3 said "Elvis Presley". The researcher asked him again "Was it Ray Charles or Elvis Presley?", and P3 confirmed the answer "Elvis". The researcher continued asking "What do you like about Elvis?" and he said "Just the way he sings... and it just, comes out right, everything comes out, and you can hear it, and it comes in, the same hairdo, where these, voices go out... yeah", and he reinforced these verbalizations with both hands moving around his ears and pointing inside his head.

The next song was *"Hit the Road Jack"* by Ray Charles. To pick this song the researcher gave him options asking "For the next song what do you prefer? Dean Martin or Ray Charles?", "Ray Charles," he said, the researcher continued "Do you prefer Georgia On My Mind or Hit the Road Jack?" and he answered, "Hit The Road Jack". He put the headphones on after a command by the researcher. When the music started, he nodded his head to the rhythm, said "that what I've seen", then slapped with his tongue and tapped his chest the beat. When the voice in the song entered, he sang too with repeated syllables of "do" "dai", "dei" and unarticulated vocal sounds. His verbalization matched the phrases but not the melody. In between he sang at least 6 times the words "no more no more", and the word "Jack" twice. He sang at least three times the military melody he sang before, he sang with mumbled sounds and clear rhythmic pattern. Once he made eye contact with the researcher, and without stopping his singing or the chest tapping, he gave a thumbs up to him. As soon as the song was over, he stopped tapping and singing and said, "very good", he was smiling and raised his hand prompting for a high five, which the researcher followed. The researcher told him to take the headphones out and he did say "Thank you". The researcher asked him "What did you just listen, was it Elvis or was it Ray Charles?" and he answered "Ray Charles", and he continued "Was it Georgia on My Mind or" and he rapiP4y said "Georgia On My Mind", the researcher continued "... or was it Hit The Road Jack?". He thought about it and said "No... what, can you repeat? Yes... it was also", the researcher said, "Hit the road Jack?", and P3 said, "Yeah, Hit The Road Jack". The researcher asked him an open question and said, "How does it feel like?", and he answered, "To me it was fun".

The fifth song was *"My Way"* by Elvis Presley. The researcher said, "For this next song we are going to do a slow one", he asked back "low", and the researcher said again "slow", stressing the S, P3 said, "Oh slow". Then he asked do you want "Dean Martin or Elvis Presley?" and he chose again Elvis Presley. When the music started, he first nodded his head to the beat, when the voice entered, he tapped the same beat on his chest and started singing unarticulated syllables. He followed the phrases of the song by extending the vowels that matched the end of phrases. He sang "had to do" with the song. When the music became richer and louder, he accompanied this by tapping the same rhythm on his chest, singing louder, and moving his arms up, and started clapping. He continued singing mumbling but sung "wonderful as you are, and ever and ever forget, and my lady forever and ever". He continued singing with unarticulated syllables, but the melody and its phrases were sung clearer. When the music decreased the energy, he accompanied this by stopping movement altogether and came back clapping and singing with softer energy. He said the word "my way" towards the three minutes of the song, just before the music rises again. He followed the new dynamics matching it with a louder voice and claps. He sang the words "my way" one more time at the end of the song, singing louP4y, and reinforcing this verbalization tapping briefly his chest at the same time. He laughed louP4y and long, rising both hands prompting a high ten that the researcher followed matching his happy level of energy. He kept laughing with a big smile, clapped and said "outstanding!". The researcher asked took the headphones out from P3's head and asked him "Who was singing My Way?", the researcher gave him options "Was it Ray Charles or..." and he rapiP4y said "Ray Charles", the researcher continued "or was it Elvis Presley" and he said, "Elvis I think was not".

The sixth song was *"Back In The USA" by* Chuck Berry. As soon as the music started, he said "Ah-ah" showing surprise with two tones, with the second note being something like a major third higher, and giving a thumbs up to the researcher. He tapped fast with his hand on his chest and sung with repeated syllables "da" for four seconds. The rhythm of his voice matched the tempo, but the melody he was singing was not related to the music he was listening, He stopped signing and continued tapping. When the lead voice entered he started singing as well with both simple ("dai", "da", "day") and unarticulated syllables, with fast and repeated rhythm (quarter-note and eight-notes), matching tempo, and with notes that were not the melody but part of the harmony, while the phrases were not consistently followed. During the instrumental part of the piano, he stopped singing and clapped fast. When the voice entered again, he also sang matching some pitches and the same rhythm and type of singing. During the guitar solo, he stopped singing and clapped again. When the voice entered again, he returned singing without stopping the clapping. When the song was finished, he kept singing and clapping for 15 seconds more. He sang the melody of the military he had sung before, with mumbled syllables and a clear rhythm of eighth notes. The researcher took the headphones out and said "Ok P3 you just listened to Chuck...", and he looked down thinking, and he said back "Chuck", the researcher continued "Chuck Be...", and he said "Chuck Bears", and the researcher said finally the complete name "Chuck Berry", and he said back "Berry".

The seventh and last song was an excerpt from *"Georgia On My Mind"*. Before putting the headphones on the researcher said to him "The next song is one of your favorite songs, do you know what your favorite song is?" and he said, "I don't know". Then, the researcher put the headphones on his head. When the song started, he did not show any changes during the introduction, until the voice started. Then, he followed singing the words "Georgia, on my mind" and said to the researcher "I knew that one", and started clapping close to the beat, he said the same words again one more time, and continued singing with syllables like "doo dee doo" and mumbling syllables. During the chorus, he kept clapping and singing unarticulated syllables and said the word "old". When the chorus was over, he said "right here" pointing at his heart. The song was faded out by the researcher and the headphones were taken out. The researcher asked him, who was singing? and he said, Elvis.

MATADOC After RS

Baseline Responses

Pre-observational	**Post-observational**
Holds water bottle with both hands	Head to L, ML, R
Head to L, R, ML	Taps water bottle
Drinks water	Holds water bottle with both hands
Taps water bottle	Hand to mouth
Trunk forward/back	Shifts position of the body

Cheers with caregiver raising bottle	Trunk forward/back
Smiles and laughs	Manipulates water bottle
Taps chest	Stands up
Talks *	Sits down
Moves leg to the front	
Scratches neck	

* P3 says to the caregiver "It's good" referring to the water.

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus on more than 1 visual stimuli. During choice-making and instrument playing he looked at the assessor and the instruments alternatively. Same as the baseline.

Responses to auditory stimuli. Consistently localizes to auditory stimuli. Turned his head and pointed with his hand with 100% accuracy. Same as the baseline.

Awareness of musical stimuli. Showed consistent interactive responses within musical exchange. During improvisation with keyboard matched tempo, followed rhythm changes, stops, tempo changes, and ending. Same as the baseline.

Responses to verbal commands. Consistently followed verbal commands. Same as the baseline. Followed the commands "touch the drum", "rub the drum", "shake the shaker", "shake it to one side", "shake it to another side", "shake it high", and "shake it low".

Arousal. Aroused throughout the session. Same as the baseline. Awake and participated actively throughout the 22 minutes of the session.

Diagnostic Outcome. Score 10. Higher-level state.

Section 2: Essential Categories Principles Subscale

Same as the baseline. Changes in facial gestures through smiling during and at the end of song presentation and instrument playing as a response to rhythm, melody, and form. Changes in eye directions by maintaining good eye contact during song presentation as a response melody and rhythm and shifting eye-direction to the instrument and the assessor during stops as a response to form. Changes in physical movement through head nodding, chest tapping with hand, and instrument playing as a response to rhythm. Changes in vocalization through tongue slaps, singing words and improvised "doo dee doo" as a response to rhythm and melody. Responses linked to dynamics and tempo when he matched with the keyboard the changes in the music played by the assessor with the guitar during improvisation.

Section 3: Essential Categories Principles Subscale

Vocalization responses showed singing the last words of phrase/music that acted as the cue. Same as the baseline. He sang the word "night", "you", and "strangers" in "*Strangers In The Night*", the word "railroad", "all", and "blow" in "*I've Been Working On The Railroad"* and the words "America my home sweet home" in the song "*God Bless America".* He also verbalized the words "forever and ever in my heart" during *"Strangers in The Night".*

Non-verbal communication showed consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. He used head nodding to show agreement, hand gestures to reinforce verbal communication and to point his choices, and interactive eye contact during musical improvisation.

Choice-making responses showed the ability to communicate a preference between two objects. Same as the baseline. He was asked to choose between drum and tambourine, and he said "drum". Then he was asked between guitar and drum and he answered drum but pointed to guitar. The assessor asked him "Are you sure that this is a drum?" and he made the correction saying, "That's a guitar".

Motor skills showed spontaneous and purposeful independent movement. Same as the baseline. He used upper extremities to improvise on the keyboard and accompany a song with drum and tambourine. He also clapped to the music, tapped his chest, and played an imaginary guitar.

Attention to task showed attention throughout the entire session. Same as the baseline. The tasks were: initial song, visual tracking, auditory tracking, verbal commands, choice-making, song presentation with instrument playing, keyboard improvisation, and closing song. Intentional behavior showed intentional response evident with goals achieved. Same as the baseline. He played music improvising on the keyboard, stated his preference for instruments, made a self-correction of the name of the instrument, and sung correct target words.

Emotional responses showed changes in expressive behaviors related to stimuli on more than one occasion. Same as the baseline. He smiled during and after musical tasks, he laughed at the end of instrument playing, he prompted a high five, and said, "right here" tapping his chest where his heart is, after keyboard improvisation and after "Strangers In The Night".

Stimuli 3 - ASPT

The procedure lasted 28 minutes and 37 seconds and the recorded messages were delivered by headphones. He took out his hearing assistive device after a request from her wife. The researcher told P3 that he would be listening to some stories about him told by her wife. He agreed with surprise saying "about me? Wow!", and then he put the headphones on.

The first message lasted 2 minutes and 8 seconds and it consisted of her wife introducing herself and talking about their honeymoon in Spain that was paid by his brother-in-law Juan. Immediately, when he heard the voice of his wife, he opened his eyes wide and looked at the researcher with surprise. Then he started interacting verbally with the recording, almost as if he was talking with someone through the phone. Said "ok, ok, P3 yes, ok, thank you, thank you very... ok... yes... Juan... yes, ok. Oh yes (laughs), castles that's right. Right. Yes. That's right, yeah. Yes (laughs) yes ma'am. Yes, right. Thank you. Right. Ok. Ok. Thank you." The researcher told him to take out the headphones and he followed. The researcher asked him "What was that story about?", and he answered, "That was a story, that was just, between, me, her, and me". The researcher continued asking "But you said something about Spain", and he said, "Spain, that was where I was at". The researcher continued "Ok. And you said something about castles?", and he said "Castles? Oh, there's a castles there, in Spain", the researcher asked "All right, and who else was there in Spain, in the castles?", and he looked down and thought about the question but he did not answer, then the researcher continued "Were you there?", and he said "Yes I was there", t a researcher continued asking "Was your wife there?", and he answered "No. When I was there, she was there later on". The researcher said "Ok. And you said something about Juan, who is he?", and he answered, "He is a friend", the researcher continued "Was he in the castle?" and he said, "no, he was just a good friend".

The second message lasted 1 minute and 40 seconds, and it consisted of the time when they were just married and lived for some time with his family, brothers, and sisters. When P3 was listening, he said "Right. Right. Yes. Potosi. Yes. Yeah. Rusell, yes. Yes. Bill Elliot, yeah. Yeah, that´s right. My sister Emma, yeah. Right. Yes. Yes. Yes. Oh yes. That. Ok. Thank you. Yeah, you are right". Even that the audio was finished he continued speaking, as he was replying to the audio, first without making eye contact with the researcher but he finished his reply looking at him. "It was just for one time, but... that we always did that. We were always come back in and, make sure that we're hallmark for any for coming in. We just sat there, and we just, make a lot, of jokes and stuff like that, and just keep going and going on. And that's the way we're always done". According to her spouse, he was referring to the parties they attended. The researcher took the headphones out and said to him "so you use to participate in parties?", and he said "Yeah. Allover", the researcher said "tell me more" and he continued "Going from Potosi all the way down, all the way up, we were in the middle of St Louis, we always going, north, and we had some people, I did after, the Basque people, they were there". The researcher said "I see. Ok. Now, you mention before Russell, who is he?" and he answered, "my brother", which was correct. The researcher asked "What about Bill Elliot? Who is he?" and he answered, "my brother", which was incorrect. The researcher continued "And who´s Emma?" and he said, "my sister", which was correct, then the researcher asked, "was she older than you?", and he said "yes". The researcher continued "What are the names of your siblings?", and he retrieved two names and agreed on two that were presented to him, the researcher asked him "Am I your brother?", and he laughed and said "no".

The third message lasted 12 seconds, and it consisted in stating that P3 decided to get out of the Air Force after being tired of Vietnam. When he was listening, he said, "You're right". The researcher asked him "What did she say?" and with some difficulties to initiate the words he said "When I was... when... when I was in... military... she made sure that my sister was way back. She came throughout this, people [unintelligible words]. And... she... all the way down in, Madrid Airways. And she really wanted to see, you know...she took me out all the way to Arizona". The audio listened again this time with speakers and the researcher asked him "Where did you go after Vietnam? Did you come back to the US or to Spain?" and he said "No, to Spain", which was correct.

The fourth message lasted 55 seconds and it consisted of the time they went back to the US to live in St. Louis, the house they lived in, how he missed being in the military, and how he went back to Vietnam. While he was listening, he said "Oh yes, yeah, St Louis, yeah, blue house, yeah. Yeah. Aunt Clare. Oh really. Yeah. Ok. Yeah. I knew that". The researcher took the headphones out and asked him "What was she saying?" and he said, "I don't remember". Nevertheless, he continued saying "People were always separated, because she could [UW] on the Air force. And, the manager, over there on the air force, he said, you can't take people out, and we are out here, in case of bombs come in. You can't do that".

The fifth message lasted 1 minute and 34 seconds, and it consisted of the day they went driving to California from St Louis, and how he departed to Vietnam from there, and how she met Roy Roger's wife. While he was listening, he said "Yes, California, yeah, yes, ok. (laughs), LA yeah, ok, right, yeah, yeah, yeah, right. Yes. Yeah. You´re right, yes. Alright., all right. Yeah". The researcher said "You said something about California. What happened in California?", and he said "That´s way up north", the researcher answered "Did you live in California?" and he answered, "Yeah, I was all over the United States, yeah, I moved one time, then go back, go up north, then go south, east, and then go out west". The researcher continued "And now you are here in the Midwest, all right, another question, when did you arrive in California?", and he said, "In that time, let's see, we got on a train, from Missouri to [UW], cause the horses, no, for sure".

The sixth message lasted 22 seconds and it consisted of the time he came back to California, but soon he left again to Vietnam for the third time, and how she left back to Spain. While he was listening, he said "Yeah, you're right", what did she say? he said, "That she, returning, to in California". The researcher played the message one more time but with speakers. The researcher said "Ok, so you went back to California..." and he completed "And I come back to Missouri". The researcher continued "And what about your wife, did she go to England or Spain?" and he said "Spain". The researcher said "Good. Well, P3, are you enjoying this? Remembering some stories about your life?" and he said "Yeah. Because, in my life, you didn't have radios, nothing, what you have there you don't have any, and every once in a while, they brought in a radio, and it was, you know, entertaining. And my dad was a [UWs] because every time it goes out, my dad was a good person, make sure, that, whatever we had to do, he could take out a part, and put it back, and it worked. And other people, they wouldn't even know what it was".

The seventh message lasted 1 minute and 11 seconds and it consisted about the time her mother-in-law passed away and the arrangements he did to help her wife get to Spain, how he got to Spain, how they moved back to the US together, and how he was back to Vietnam for the fourth time. While he was listening, he said "Yeah, you're right (laughs). Yeah. Yeah. Oh. Oh yeah. My, my time in, yeah. Ok. Yeah. Oh ok". The researcher took the headphones out and said, "Back to where?" and he answered "Vietnam". The researcher continued "when?", and he said "I don't even know?", the researcher asked "How many times did you go back and forth?" and he said, "Depends on, what had to do, the managers of the Air Force, they would say ok B, you have to go to North Carolina, or, yeah, so you had to go".

The eighth message lasted 2 minutes and 12 seconds and it consisted about the time she was leaving again in the US in California alone with their first baby, while he was in duty, how 7 months later he came back, and how P3's mother went to California by train from Missouri to be with her and her granddaughter while he was in Vietnam. While he was listening, he said "Oh, ok. Yes, yes. Right (laughs). Yeah. Yeah yeah, right, ok, yeah. Right, right. Yeah, well. Right. Yeah yeah, ok. But, what? yeah. Oh. Yeah. Never. Yeah. Yeah. (Laughs). Yeah". The researcher asked "What did she say?" and he answered, "It's hard to say because, my wife was out, and I have to go out, and the manager, he said come on Beetle we gotta go up here, and [UWs] clothes, you gotta go all up north, and if it wasn't getting at, and he said ok, we gotta get out of here and we had to go way out to south". The researcher said, "That must have been tiring, weren't you tired?" and he said, "We had no choice". The researcher asked him "The recording mentioned something about your first baby being born by then, what's her name?", P3 thought about the question and answered "Anabelle", which was not correct.

MATADOC After ASPT

Observations during periods of rest were similar between pre and post observational periods and compared to the first block.

Baseline Responses

Pre-observational	**Post-observational**
Head to L, ML, R	Head to L, R, ML
Hold water bottle with both hands	Grabs sides of the chair with both hands
Rubs knee/leg	Scratches ear
Sings "doo dee doo"	Adjusts table
Leg movement to the front	Sings "doo dee doo"
Drinks water	Taps table with fingers
Laughs	Hands together
Taps foot	Checks pockets
Hand to mouth/face	Hand to mouth
Taps lap	Tongue slaps
Taps table with fingers	Talks with assessor*

* P3 looked at the assessor and asked "How long have you been on this?", and he asked back "What do you mean?", P3 said "How long when you come in here, how long you get to stay in [UWs] in music?. The assessor asked back "Do you mean in your home or in the US?", and he answered, "In the US", then the assessor answered.

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. P3 could focus alternatively on more than 1 stimulus. Same as the baseline. He tracked a picture of Chuck Berry in all 4 quadrants. The stimulus was presented at 2 feet. During choice-making and instrument playing he looked at the assessor and instruments alternatively.

Responses to auditory stimuli. P3 consistently localized auditory stimuli. He tracked music presented to his midline. Same as the baseline. He turned using the A3 and D#6 hand chimes with 100% accuracy in 10 out of 10.

Awareness of musical stimuli. P3 showed consistent interactive responses within a musical exchange. Same as the baseline. During song presentation he clapped following the tempo, copying vowels, followed start/stop, filled-in prompted lyrics, and matching pitch with his voice, especially with *"Strangers In The Night", "God Bless America", and "I´ve Been Working On The Railroad".* During keyboard playing, he followed turns and then improvising he matched tempo and style, followed a ritardando, and the final stop.

Responses to verbal commands. P3 consistently followed verbal commands. Same as the baseline. Same as the baseline. He followed the following commands: "touch the drum", "grab the tambourine", "shake it high", and "shake it low".

Arousal. P3 stayed aroused throughout the session. Same as the baseline. He was engaged and participated actively.

Diagnostic Outcome. Score 10, Higher-level state.

Section 2: Essential Categories Principles Subscale

Same as the baseline. Changes in facial expression through smiles during and after musical tasks as a response to rhythm, melody, and form. Changes in eye direction through shifting it between instrument and assessor during turn-taking and stops as a response to form. Changes in physical movement through instrument playing, clapping, and foot-tapping as a response to rhythm. Changes in vocalization through singing as a response to melody and timbre of the voice. He filled-in prompted lyrics as a response to form. During keyboard improvisation, he matched the intensity and followed ritardando and tempo changes as a response to dynamics and tempo.

Section 3: Essential Categories Principles Subscale

Vocalization responses were rated as singing the last words of phrase/music that acted as the cue. Same as the baseline. During the song *"Don't Be Cruel"* he mumbled, he copied vowels at the end of phrases, but he filled-in the words "from in my heart" at the end of a phrase. These words were prompted by the assessor by pointing with his hand his own chest where the heart is, and although the correct words were "cross my heart", he sang them with correct pitch and rhythm. During *"Strangers in The Night"* he sang last words like "night", "you", and also verbalized different lyrics, but emotionally connected like "forever and ever in my heart", repeating these many times.

Non-verbal communication responses showed consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. These were head nodding to show agreement, hand gestures to reinforce verbal communication, pointing with hands to show choice, and interactive eye contact during instrument playing.

Choice-making responses showed communication of preference between objects. Same as the baseline. He was asked his preference between guitar and piano and he chose guitar by saying the name. Additionally, he was asked what he just played guitar or piano, and he said piano, and additionally said he did not play the piano when asked.

Motor skills responses showed spontaneous purposeful independent movement. Same as the baseline. He showed the movement of upper extremities when playing keyboard, tambourine, egg shakers, clapping, and tapping with his hand on the table.

Attention to task responses showed attention for the entire session. Same as the baseline.

He attended during the 30 minutes of the session. The tasks presented were initial song, visual tracking, auditory tracking, verbal commands, song presentation with instrument playing, keyboard improvisation, choice-making, closing song.

Intentional behavior responses showed intentional response evident with goals achieved. Same as the baseline. Based on the fact he made choices between instruments, consistent exchange of music during instrument playing tasks, and filling-in words through singing.

Emotional responses showed changes in expressive behaviors related to stimuli on more than one occasion. Same as the baseline. He smiled during and after musical tasks, especially after instrument playing, verbalized louP4y "all right!" after *"Don´t Be Cruel"*, and said, *"Oh blueberry hill right here!"* pointing at his heart, after *"Blueberry Hill"*.

APPENDIX E: MATADOC BASELINE REPORT, NARRATIVE OF CONDITIONS, AND MATADOC POST-TEST REPORTS FOR P4

MATADOC Baseline Report

Observed Responses at Rest

During the pre and post behavioral observation periods of each assessment session P4 demonstrated positive behaviors during periods of no stimulation. She showed head rotations, movements of the right upper extremity (shoulder, arm, hand grasp, and finger dexterity), and bilateral movement of lower extremities, where the left produced only small movements of the feet and ankle, compared to the right that showed a big movement of the whole leg. She initiated a conversation with the assessor in sessions 1 and 2 and was especially talkative in session 1. In sessions 3 and 4 she showed very few behaviors and closed her eyes to sleep.

Session 1

Pre-observational	Post-observational
Head to R, C	Head to R
R hand manipulates strap	R feet small movement
Talks to/with assessor*	R hand manipulates strap
R hand under chin	R hand supports verbal communication
L foot small movement	R hand touches her hair on L side
R arm on the armrest	R hand touches the mouth
R hand reinforces verbal communication	Talks to assessor**
R hand straightens shirt	
R leg up and then down	
R hand caress left arm	

*: P4: Are you looking for real organ students? NE: No, it has to be people that enjoy music, like yourself, right? P4: Well, I enjoy some music, not everything. NE: What do you enjoy? P4: Individual piano work that isn't too much out of this world kind of stuff. NE: What do you mean by that? P4: Well, it's pretty normal. NE: For example? P4: Music put up by normal students, I don't know what that means. NE: Like classical music or more popular? P4: More

classical. NE: Do you mean like Handel? P4: That would be good. NE: What about Mozart? P4: A little bit of that. NE: What about opera? P4: Not, in particular, some opera might be more enjoyable than others... My husband likes organ so I've done a little bit with him, but mostly it is accompanying music... Is this just a music program going on today? NE: Yes, this is a music therapy program going on today. P4: I noticed that in the wing we were sitting in they were all doing all some kind of music. NE: Yes, so you've heard some music around. P4: I've heard a little bit of what they were doing today or yesterday. NE: Yes, that's correct. I was singing the song "KKK Katy", do you know that song? P4: No, but maybe I have heard it.

**: P4: This looks like the stuff he took out of the bedroom I use (points at objects from the room that belongs to her husband). Oh, I know, he has been interested in different kinds of lotions, that sort of thing, he had quite a bit of that on that shelf right there... That doesn't [UWs] better than I can on guitar or classical music... We have a daughter that plays quite a bit of the music he likes too. NE: What did you like to play? P4: I used to like a book that had some classical music. I cannot remember the book right now, but it wasn't the one that we play today. And I know my husband likes classical music. NE: What's the name of your daughter? P4: Jane. NE: Do you think Jane will know what is the book? P4: Probably, because she used those books... She didn't get into the guitar. Her dad used to play the guitar. Actually, she had 2 dads, the first one liked the guitars, the second is the current one.

Session 2

Pre-observational	Post-observational
R hand movement to open an envelope, take out a letter and read it.	Head to R
Talks to assessor*	L foot small movements
R foot small movements	R foot small movements
Head to C, R.	

*: P4: So it starts with a rest.

Session 3

Pre-observational	Post-observational
Head to C	R hand touches face/neck
R thumb caressing L arm	Eyes open/closed
R foot small movements	Appears sleeping
Eyes open/closed	
Appears sleeping	

Session 4

Pre-observational	Post-observational
Head to C, R,	Head to C, R
R hand caressing L hand	Eyes open/closed
R hand under chin	Appears sleeping
Eyes open/closed	
Appears sleeping	

MATADOC Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Pictures of significant instruments and well-known baroque composers were used as stimuli: a pipe organ, Bach, and Handel. These stimuli were presented at approximately 2 and 3 feet from her eyes. In all the 4 sessions she consistently followed the stimuli on the 4 quadrants (Left, Right, Up, and Down). To keep her engaged in tracking a simple prompt of "keep looking" was enough or asking a question about the picture. She also tracked the movements of the assessor. She alternatively looked at two different instruments during choice-making, or guitar and assessor during song presentation, or score and piano during score reading. Therefore, her visual responses categorized for the higher level showing that she could focus alternatively on more than 1 visual stimulus.

Responses to auditory stimuli. Guitar playing and singing were presented in P4's midline. During this task, she kept consistent eye contact and spontaneous correct singing of words with the assessor. During a second task of tracking auditory stimuli, two hand chimes were used A3 and D#6. The stimuli were presented close to the ear with a mezzo-piano volume and outside of her visual field. She consistently localized all the sounds by turning her head/eyes, pointing with her finger, and saying correctly left and right.

Awareness of the musical stimuli. P4 showed consistent interactive responses within the musical exchange in sessions 1 and 4, and inconsistent interactive responses within the musical exchange in sessions 2 and 3. In all 4 sessions, she sang all the words of the songs presented matching them with the rhythm of the songs played by the assessor. Only two songs were not sung by her and when asked she said that she did not know them. She sang with a low tone and soft dynamics like the one she used to speak. She improvised with the keyboard in sessions 1 and 4 following tempo and alternating turns with the assessor, playing in all spaces provided for her to fill in. In session 1 she also read a score accurately on rhythm and pitch but skipped some parts. In session 4 she moved the hand of the assessor to the tempo and rhythm of two different recorded pieces of baroque music (Bach's Brandenburg 1, and Handel's Water Music). In sessions 2 and 3, musical exchanges were similar but more inconsistent. When using the keyboard, she followed all starts of music but not stopping. This was observed also playing the tambourine to the song "How much is that doggie in the window?". In both sessions, she also started sleeping towards the end of songs and keyboard playing, where she was still playing but with eyes closed, and not stopping with the assessor.

Response to verbal commands. P4 responded consistently to verbal commands in all 4 sessions. She followed the following commands "touch the drum", "shake the shakers", "shake it high", "shake it low", "shake it to your left", "shake it to your right".

Arousal. P4 stayed aroused throughout the protocol in session 1 and slept between 10% and 15% of the protocol during sessions 2, 3, and 4. However, she was easily awakened by calling her name or giving her the verbal command to wake up.

Diagnostic Outcome. P4's scores were congruent with the presentation of someone in Higher-Level State. In the 'Essential Categories Principle Subscale' over the four MATADOC assessment sessions in the response categories (visual, auditory, awareness of musical stimuli, verbal commands, and arousal) P4's total scores were: Session one 10 (Higher-level state), Session two 8 (Higher-level state), Session three 8 (Higher-level state), Session four 9 (Higher-level state).

MATADOC Section 2: Behavioral Responses to Music

P4 showed several positive responses to music. Changes in facial gestures were observed only once in session 1 in the form of a big smile when being asked if she would like to read more scores in the following sessions. Changes in eye contact through engaging in eye contact with the assessor during song presentation and looking towards the sound during auditory tracking, towards the drum during instrument playing, and shifting gaze between guitar and assessor or keyboard and assessor during song presentation and keyboard improvisation as a response to melody and timbre. Changes in physical movements with right upper extremity through playing keyboard, drum, shakers, and tambourine, during song playing and improvisation as a response to melody, rhythm, and form. Also, she moved the arm of the assessor to recorded music as a response to tempo and rhythm. Changes in vocalization through song singing to preferred songs as a response to melody and form.

MATADOC Section 3: Clinical Information to Inform Goal Setting and Clinical Care

Most of the areas covered in this section were rated high as strengths for P4, except for attention to task, emotional responses, and motor skills. Attention to task fluctuated during sessions, emotional responses were infrequent and motor skills were rated as a developing area, which is the highest possible level of the assessment.

Vocalization responses were rated with the highest score as she sang all the words to familiar songs. These songs were: "How Great Thou Art", "How Much Is That Doggie In The Window", "A Bicycle Built For Two", "I've Been Working On The Railroad", "Hallelujah", "Home On The Range", "You Are My Sunshine", "I Need Thee Every Hour", and "Rock Of Ages".

Non-verbal communication was rated with the highest score as she showed consistent use of spontaneous and appropriate social communication gestures. These behaviors were observed during a conversation, song presentation, auditory responses, and instrument playing. She nodded her head to say yes or no, added hand gestures to support/reinforce verbal communication, used interactive eye contact, received instruments when handed them to her, pointed with a finger to show where the sound was or to make a choice.

Choice-making was rated high as she communicated consistently preference between 2 objects. She chose to prefer low pitch to high pitch, piano sound to organ sound of the keyboard, keyboard to drum, and keyboard to guitar.

Motor skills were rated as high as possible as she showed spontaneous purposeful independent movement, mainly through her right upper extremity. She played the keyboard with finger dexterity, played the drum also with fingers and movement of the wrist, and shook tambourine and egg shakers with hand grasp and arm movements.

Attention to task was rated high in the first session where she attended for the entire session, but in sessions 2, 3, and 4 she slept for some periods (no more than 15% of the total session), scoring as attending for entire musical tasks. Consistently she attended to visual, auditory tracking, choice-making, score reading, and verbal commands, but she slept for brief periods during the initial song, song presentation, instrument playing, keyboard improvisation, and usually towards the end of the tasks.

Intentional behavior was rated high as she showed intentional response evident with goals achieved. This based on her ability to make choices, play instruments with a musical exchange with the assessor, sing songs, recognize pictures, read scores, and reminisce.

Emotional responses were rated low on sessions 2 and 3 where no changes in expressive behaviors were seen, and a little higher on sessions 1 and 4 where changes in expressive behaviors were seen in only 1 occasion. In session 1 she smiled after being asked if she would like to read more scores on the following sessions, and in session 4 she sighed deeply during keyboard improvisation after the assessor played a chord during a turn-taking task.

Relations between MATADOC, the GDS, and the CDR

P4 was assessed using the CDR scale by the Student Music Therapist. In the CDR scale, she scored a 3, which accounted for severe level of dementia. She rated severe in orientation, home and hobbies, and personal care, which meant that she was oriented to person only, no significant function at home, and required much help with personal care, and had frequent double incontinency. She rated moderate in memory, community affairs, and in judgment and problem solving, which meant that she showed severe memory loss, with highly learned material retained and new material rapidly lost, appeared well enough to be taken outside a family home, with no pretense of independent function, and severely impaired in handling problems, similarities and differences, and social judgment usually impaired.

In the GDS she rated a 6, which accounted for Moderately Severe dementia and severe cognitive decline. However, some parts of the GDS description did not adjust to her case. She retained well the names of her siblings and husband, she was fully assisted on all ADLs with double incontinency, and she was disoriented for time and place. Additionally, she showed delusional behaviors, as she thought she was in some other building and was unaware of her condition and history of stroke.

The MATADOC showed that despite memory impairments her ability to remember complete lyrics of songs, and recognize musical instruments and some composers, was unimpaired. Her ability to read scores showed slight impairment, but when the piece was easy (quarter notes, slow rhythm) she showed the ability to read well although skipping some parts. She did not show agitation behaviors throughout the assessment.

Results and Recommendations of the MATADOC Assessment

The MATADOC outcomes indicate that P4 was consistently responding at a Higher-Level State of awareness. She demonstrated awareness of herself and her environment although sleeping behaviors partially interrupted her arousal. This affected sometimes her ability to interact fully with the music. However, she was easily awakened to function and respond to the musical tasks and showing ability and awareness of the spaces provided for her to play and interact.

Comparing the pre and post observational periods no changes were observed. She appeared very talkative in the first session, and progressively fewer behaviors were seen in the next ones, to the point where sleeping behaviors were seen in sessions 3 and 4 in both pre and post observations.

During the assessment, she showed the ability to track more than one visual stimuli, consistently localize auditory stimuli, interact within the musical exchange, follow verbal commands, and stay awake during most of the session. She showed responses to elements of the music like rhythm, melody, tempo, timbre, and form, which triggered responses in her eye direction, vocalization, and physical movements. She vocalized all of the words of familiar songs showing good long-term musical memory, communicated with appropriate non-verbal communication, made choices between two objects, showed purposeful movement of right upper extremity through instrument playing, ability to attend to musical with intermittent sleepiness, ability to produce intentional behaviors seen in instrument playing, choice-making, score reading, identification of musical artists and instruments, and low emotional response observed only in 2 out of 4 sessions.

In conclusion, P4 did not show deficits in awareness, therefore her cognitive deficits should be addressed to other areas most probably to orientation to reality, short-term memory, executive function, mood disorders, and also arousal. Her high responses in a musical context suggest that music therapy was highly recommended to work on maintaining her cognitive, spiritual, emotional, physical, and social areas. Including her family to further connect with her could be highly beneficial too to improve her quality of life and from her loved ones.

Stimuli 1 - ASPT

The procedure lasted 28 minutes and consisted of listening to recorded messages through a speaker and following-up with the researcher through questions presented to P4. The messages were recorded by her daughter and her husband and the procedure was briefly explained to the participant before listening to the messages. Her daughter spread the word "mom" throughout the messages and did not call her by her first name, her husband did use her first name at the beginning of the message. The follow-up part was longer than the actual listening of messages. For the most part, she listened to the messages engaging in eye contact with the researcher and towards the speaker.

The first message was told by her daughter and lasted 1 minute and 7 seconds, and it consisted of a funny story when P4 was about 4 years old. She had a kitty that she put in the washing machine saying it to her "swim, swim". When she first heard the voice of her daughter, she looked at the researcher and nodded her head up and down lifting her eyebrows. During the recorded message she said to the researcher "I remember that". Then, when the message was over she said to the researcher "That must have been fun looking for that one", and the researcher said "Was it fun for you?", and she answered, "I don't know, probably it did more than once". All this was said with a rather flat affect and a monotone voice as usual on her. The researcher followed up asking "What was the name of the kitty?", and she answered "Kita", the researcher continued "And you were what?" and she said, "about 2 or 3". He then asked "And how did they found out", and she answered "my mother saw me put the cat in or else take it out", and "what did she say to you?", and she answered, "I think she said the kitty doesn't swim". He asked "Was that a funny story for you or not?" and she answered "Well for my age I guess I'd say it was funny, being then about four", he continued "Is it still fun for you?", and she answered, "Yeah, but I haven't told that for a while". The researcher asked her "I have another story for you, do you want to hear it?" and said nodded her head saying "yes".

The second message was told by her daughter, it lasted 3 minutes and 40 seconds, and it consisted of when the father of P4 was hit by a car during a snowstorm, while he was changing a tire. P4 was in the car, and her door was open, his father was behind her door, and the car hit the door taking it with him. They found him buried in a pile of snow, with no damage. They said that it was a miracle and that he was saved by an angel and prayed to thank the Lord. While she was listening, she said to the researcher "Grandpa meaning my dad", the researcher paused the recording and followed-up "What was the name of your dad?" and she said "David". The researcher continued the recording and while listening she said to him "I remember that" while nodding her head. During the recording, her daughter mentioned they found the father in a snowbank. The researcher paused the message again and asked her "What´s a snowbank?" and she said "A snow pile" while she put her hand flat parallel to the ground showing the height of the pile. The researcher asked for clarification "So was he hit by the car?" and she said, "No, he might have been hanging on to the door, but he did survive the crash". He continued the recording till the end, and then he asked her "How old were you?", and she said "about four", the researcher continued "Do you remember where were you going?", she answered "North Carolina, my dad would be hitting to his service", the researcher said "I think your daughter said he was being discharged and you were moving to Michigan?" and she answered, "I don't think he was being discharged, but at least he would be able to go back to Michigan". The researcher continued "So this happened in Michigan?" and she said, "On the way... we were on the Carolinas where all this happen", the researcher summarized "So you were on the Carolinas, going to Michigan..." and she clarified "going back", he validated that and continued "right, so going back to Michigan, and a snowstorm came in and that's how everything happened", and she clarified again "I don't think it was a storm, but at least there was a high snow on the sides" showing again the height of the pile with her hand. The researcher continued "I see. And what did you do when you found out that your dad was safe?", she said "Well of course, when we realized he was okay everybody was thankful to the Lord", and he continued "Were you praying?", and she nodded her head and said "yes". The researcher said "That must have been scary", and she said "Sure it was, he was on the ground, next to the car, and the door was open... but he made it, and we just thank the Lord he was ok", he followed-up saying "an angel right? According to what your daughter was telling", and she said "Yeah, that was what my mother said, she said he must have picked him up and put him down where it was safe", the researcher continued "What do you think about that?" and she answered "It's a possibility, certainly the Lord protected him whether it was an angel or the Lord we don't know", and he said "Right, anyway, something divine... it's a very impressive story". She continued saying "Well and I was only about four, my sister V (name of her daughter) would have been less, and my mother and my dad about 5 probably when all that happened", the researcher said "Who would be five?", and she continued "my mother and my dad were about 5, well maybe not, I was probably about five", the researcher followed-up saying "Right, so if you were 5 they should have been probably older than that..." and she said, "They would have been...my dad was about... fifteen when all that happen... he was just about [UWs] and we didn't know that much about it, about cars, but we knew enough to stay away from the cars... that crash on the side where I was sitting, the car that caused the window glass [UWs]". The researcher asked her "Did the other car stopped?", and she said, "It seems that it kept going". The researcher acknowledged all that she shared and asked her "I have a third story for you, would you like to hear it?", and she nodded her head saying "Yes, let's see what she got".

The third message lasted 1 minute and 22 seconds and consisted of memories about how P4 used to feed the hummingbirds in her backyard. At the end of the message, her daughter said, "I hope you remember about this" and P4 nodded her head and said to the researcher "I do remember". The researcher said, "You do remember?", and she said, "Yeah, I remember the feeders and the hummingbirds coming to drink from them where I used to live". The researcher continued "where did you use to live?" and she answered "Across the street where the trailer is right now... the trailer was parked in the opposite side of the street, at the other side of the curb", the researcher followed-up "I meant what town?" and she said "Menomonee", and the researcher continued "Did you ever live in this town? (he named the town)", and she answered "I did live in X for a couple of years when V (her daughter) was smaller, we took our trailer there, it was quite an experience for her, she loved their little kitty that we bring with us, we used to call it kitty cat... I guess I had wondered a couple of years earlier with that, decided to take our trailer and take us to North Carolina, but I just called it kitty cat". The researcher said "Now let me get back to the memories of the hummingbirds, did you plan to care for those hummingbirds or was that something that just came up?", and she said "Well we had some feeders outside in the backstairs and in the downstairs, and they just liked to come to the feeders", the researcher asked "What did you put in the feeders?" and she said, "A kind of sweet honey they recommend", the researcher followed-up "just honey? or mixed with water?" and she said, "mixed with water, it tastes good to birds". The researcher continued "Was this something you enjoyed watching the birds?" and she nodded her head saying "Yes, we had... let me see, one, two, three, four, five probably windows where we watched them". The researcher continued asking "Do you remember the colors of those hummingbirds?", and she answered, "Well I suppose they were blue and greenish", the researcher asked, "Any black", and she said "I didn't see any black... I remember blue". The researcher summed up and said, "Well these were lovely memories" and she said, "Well we always liked it, cause we were all there, my daughter my dad too, and maybe the older boy". The researcher said to her "I have one more story, do you want to hear it?" and she said, "From my daughter?" and he said "yes".

The fourth message lasted 52 seconds and consisted of memories about flowers that she planted on spring in her backyard, including one called Surprise Lily in memory of P4's mother. When the recorded message was over, she repeated the last words "see you soon mom". The researcher said "Well, tell me something about this passion for flowers you have", and she said

"Well I have planted flowers all around this little bird feeders, and there was water there", she said this while drawing a circle with her index finger. The researcher continued "And what is this Surprise Lily?", and she answered "Surprise Lily it's one many people plant in their yards and if they have forgotten they planted it's a surprise when it comes up", the researcher said "Oh! and that's the reason for the name?" and she nodded her head up and down. The researcher asked, "What color was yours? and she answered, "The ones we had were pretty much blue to red", the researcher said to her "Wow! I've never seen a blue lily before" and she said, "You have to look at the garden store in spring and see if they have some". The researcher then asked "What do flowers mean to you?" and she answered "It's a variety that God put for us", he continued "And how did they make you feel when they appeared?", and she said "Well since we planted them, we were glad that we had planted them, they were special coming up when they did... But the biggest thing about those plants was going through the mountains back in North Carolina, and these guys were growing it, I don´t remember if it was in a pod, or this [UWs], outside the trailer... I think my mother used to say God protected us with the [UW] because we'd be going through the Carolinas, on the way where my dad took to get on a boat [UWs] that would be going to the [UWs] boat that would be [UWs] those birds... My dad, I believe he liked the birds like all of us".

The fifth message was told by her husband and lasted 16 seconds, and it consisted of a simple memory stating when and where they met for the first time 16 years ago. Once the message was over, she said to the researcher "It was exciting... I knew of him, but I didn't know him very well, so when he came up to this camp, where we had parked our trailer, he had stories to tell about the trailer, and I would have been probably fourteen", the researcher answered

"Didn't he say this was 14 years ago?", she said, "So we met after the bird experience, and we had quite a few years calling it Happy in Honey Rock".

MATADOC After ASPT

Baseline Responses

P4 showed similar responses at rest compared to the first MATADOC.

Pre-observational	**Post-observational**
Head down, front, and to right	Head to the front, down, left, and to right
R arm/hand small movement	Talks to/with assessor*
Manipulates strap with the right hand	Right hand reaches to the front
Right foot small movement	Right hand small movement
Right hand touches right eye and adjusts glasses	Right hand points with index
Right hand under chin	

*: P4: It sounds like you have the kids to participate with you *(maybe because there was noise coming from people outside)*. Did you hear that my daughter and I took the red car down to the... from the beach, and played it on?; NE: Played what? P4: That first number, we took the car and we just played some of the music. NE: What songs did you play? P4: Daisy, Daisy, give me your answer do. NE: Really? P4: It was the one that was predominant in my mother's thinking, and she taught it to me and then she taught it to my daughter, maybe the boys too, I don't remember. NE: What other songs? P4: Whatever we could play on the guitar, my mother knew a few songs and taught them to her children.

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus alternatively on more than 1 visual stimulus. She tracked a picture of Bach in all 4 quadrants. Looks alternatively at two instruments presented in front of her. Same as the baseline. Additionally, she immediately identified the composer in the picture.

Responses to auditory stimuli. Consistent localized auditory stimuli. She identified hand chimes (A3 and D#6) in 6 out 8 opportunities, and egg shakers in 2 out of 2. Same as the baseline.

Awareness of musical stimuli. Showed inconsistent interactive responses within musical exchange. During song presentation, she sang following the tempo and rhythm of the words with the assessor. At the same time, she played the egg shaker shaking it with eighth notes, following the tempo. However, she did not follow tempo changes or stops within the music. She did follow the final stop. During keyboard playing she started and stopped with the assessor, but did not follow changes of dynamics, rhythm or tempo, she played with long notes and appeared to be playing on her own. Like baseline.

Responses to verbal commands. Consistently followed verbal commands. Same as the baseline. She followed the following commands "touch the drum", and "touch the guitar ".

Arousal. Aroused throughout the protocol. She actively participated throughout the 22 minutes of the session. Same as the baseline.

Diagnostic Outcome. Score 9, Higher-level state.

Section 2: Essential Categories Principles Subscale

Like baseline. Change in facial expression through one smile during "Bye and bye" song, she said that she recognized and smiled, then as a response to the melody. Changes in eye direction by maintaining eye contact during song presentation as a response to rhythm and melody. Changes in the physical movement of right upper extremity when she played keyboard and egg shaker to the music of the assessor, as a response to rhythm and form. Changes in vocalization through singing "A bicycle built for two" as a response to the melody. Responses to timbre were observed in choice-making as stating a preference for guitar, and then for the drum.

Section 3: Essential Categories Principles Subscale

Her responses in this item were the same as the baseline. In the vocalization item she scored high as she sang all the words to familiar songs. Same as the baseline. She sang the first verse and chorus of the song "A Bicycle Built for Two", and she even stated that she always sang "give me your answer do", instead of "give me your answer true".

Non-verbal communication was scored high as she showed consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. These behaviors were observed in response to a conversation, instrument playing, and choice-making. She used hand gestures to support verbal communication, used interactive eye contact when playing instruments, and pointed with a finger to make choices.

Choice-making was rated high as she communicated consistently preference between 2 objects. Same as the baseline. Two instruments were presented at the same time, she chose the drum over the tambourine and the guitar over the drum.

Motor skills were rated as high as possible as she showed spontaneous purposeful independent movement with her right upper extremity. Same as the baseline. She played the keyboard with finger dexterity and shook egg shakers with hand grasp and arm movements.

Attention to task was rated high as she attended for the entire session. Like baseline. She participated actively through the tasks and talking throughout the protocol with the researcher. Initial song (2'30"), visual tracking (1'40), auditory tracking (3'), verbal commands (1'20"), choice-making (1'), song with instrument playing (2'), keyboard improvisation (2'40"), closing song (1'),

Intentional behavior was rated high as she showed intentional response evident with goals achieved. Same as the baseline. This based on her ability to make choices, play instruments within musical exchange with the assessor, sing a song, recognize the picture, and dialogue with the assessor.

Emotional responses showed changes in expressive behaviors related to stimuli on 1 occasion. Like baseline. She smiled once during the closing song as she initiated verbal interaction with the assessor asking him "Is that the one you were playing the other day?".

Stimuli 2 - LMT

The procedure lasted 28 minutes. The original objective was to increase signs of elevated mood; however, it was changed to increase her arousal state as she started sleeping and did not respond to calling her name or verbal commands to wake her up. The techniques used consisted of playing familiar songs and sounds to her midline, right, and left ear. Songs were played a capella, with guitar, with drum, paired with a gentle touch of hands, movement of arms to the rhythm of the music, entrained to her breathing rate, assisting her to play instruments, and using different dynamics. Also, sounds were played to both sides using drums, guitar, and shakers. In between each application the researcher tried to awake her calling her name and asking her questions about the songs.

The first application lasted 4 minutes, and it consisted of initiating the session with a preferred song, discuss the feelings that evoked this song in P4, and prompt facial expressions regarding these feelings. The researcher sang the song "How Great Thou Art", and she responded singing the words with a soft voice and low pitch. After the chorus, she started closing her eyes and kept moving her lips during the second verse, but without sound. The researcher continued singing increasing the dynamic, but she did not open her eyes. The researcher stopped the guitar and kept singing providing a gentle touch of hands and including her name in the song, but she did not respond and appeared already sleeping.

The second application lasted 3 minutes and 25 seconds and consisted of playing single sounds to both of her ears, improvising simple melodies paired to her breathing rate while using her name and the name of the instrument. Sounds of guitar, shakers, and, drums were used and played close to her ears. She did not respond with any behavior.

The third application lasted 6 minutes and consisted of playing the song "I've Been Working on the Railroad" accompanied by the drum, first entrained to her breathing rate, then moved to a faster tempo, to finally assist her to play the drum. First, the drum was played by the researcher and sung to her midline, and then the mallet was put on her hand to play the drum with hand-over-hand assistance while the researcher kept singing. She responded by tapping her right foot and moving her right hand during the fast tempo but did not open her eyes. She kept moving her right hand for 7 seconds once the song was over as if she was still playing.

The fourth application lasted 8 minutes and 20 seconds, and consisted of singing spiritual songs a capella, first waving her hand to the music, singing close to her both ears, and assist her to strum the guitar to one of the songs. One additional song out of her familiar repertoire was included towards the end, and one fast familiar song was included at the end. The researcher started singing the song "How Great Thou Art" paired with a gentle touch of hands and waving her right hand to the tempo of the song. As soon as the researcher started waving her hand, she continued moving it from side to side on her own and to the tempo, but still without opening her eyes. Also, her hand kept the grip of the mallet that was placed before. The researcher moved close to her ear and kept singing to both sides and she started moving her lips, singing the song, with a very soft volume, while still moving her hand. The researcher stopped singing and she kept moving her hand for 10 more seconds. The researcher changed the song to "He's Got The Whole World In His Hands" and sung it close to her ears and alternating sides. She sang the words with the same soft volume. The researcher moved to her front, grabbed the guitar, and provided hand-over-hand assistance to strum the guitar with her hand, while the researcher kept singing the song. She did not initiate the movement but kept singing the words, even filling in the blank at the end of a phrase when the researcher stopped singing. A third song was presented "I Need Thee Every Hour". The researcher sang close to her ear and immediately she started singing softly and moving her right hand slowly matching the tempo of the music. The researcher kept singing and provided a gentle touch to the arm while waving it to the tempo of the song. She responded by singing softly the song. Additionally, the researcher tried a song out of her familiar repertoire but age-appropriate and that matched her relaxed state. The researcher sang a capella the song "Oh Danny Boy" close to her ears, and after 40 seconds she started moving slowly her right hand from side to side. The researcher closed the song and asked her "D, do you know this song?" and she answered "slightly" without opening her eyes. Finally, the researcher snapped his fingers with a faster beat and started singing "This Land Is Your Land", she immediately moved her lips as if she was singing but without making a sound. At the same time, she moved her right hand slightly but faster, and the left hemiparetic leg with a movement coming from the hip, as if she was keeping the beat. She stopped this last movement after the first verse was over. The researcher kept singing and moved to the front to tap her feet to beat of the music. She did not move her feet again but kept her hand moving and filled-in the blank with the last word of the song.

The fifth application lasted 4 minutes and consisted of singing the song "Rock of Ages" a capella while waving her both arms from side to side and promoting deep breathing. When the researcher started singing, she responded singing the words appropriately and filling-in the blank at the different parts of the verse and chorus. The researcher repeated the chorus and the first and second verses three times. When the researcher prompted her to breathe in and out, she followed, but without opening her eyes. This was repeated three times. Finally, a fast tap with her hands on her laps was prompted with hand-over-hand assistance and verbal cues, by saying repeateP4y "tap, tap" and every time faster. One more deep breath was prompted which she followed, and she slightly moved her head forward. During the pause, she started slightly blinking her eyes and moving her head like awaking but closed them again and remained still but moving her right hand slowly from side to side.

MATADOC After LMT

Baseline Responses at Rest

P4 showed similar responses at rest compared to the first MATADOC. Even though she slept during previously observed rest periods, this was the first time that she started with her eyes closed during the pre-observational period. At the same time, it was the first she that she appeared fully awake during the post-observational period, after showing a low wakefulness state.

Pre-observational	**Post-observational**
Right hand swaying movement (rhythmic)	Talks with assessor*
Eyes closed	Head looking up, and to right
Brief opening of eyes	Right hand small movement, touching/grabbing/caressing armrest
Brief right foot small movement	

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus alternatively on more than 1 visual stimulus. Same as the baseline. She tracked a picture of Handel in all 4 quadrants. During choice-making, she looked at both instruments presented alternatively.

Responses to auditory stimuli. Consistent localized auditory stimuli. Same as the baseline. She localized sounds played with hand chimes (A3 and D#6) in 10 opportunities. Her response was slower than usual, and her head-turning was not clear, but she was able to point the side correctly.

Awareness of musical stimuli. Showed inconsistent interactive responses within musical exchange. Similar to baseline. During song presentation, she sang the words of "She'll Be Coming Round The Mountain", and "He's Got The Whole World", matching tempo and rhythm of the assessor. During keyboard playing, she followed turns with the assessor, but she stopped playing twice and she had to be prompted to reinitiate interaction. During improvisation, she played notes but did not appear to follow the music of the researcher.

Responses to verbal commands. Consistently followed verbal commands. Same as the baseline. She followed the following commands "touch the drum", "shake the shaker", and "shake it fast".

Arousal. She stayed aroused between 50% to 90% of the protocol. Like baseline. She stayed awake for most of the protocol but stayed with her eyes closed during the first 4 minutes of the "Hello Song".

Diagnostic Outcome. Score 8, Higher-level state.

Section 2: Essential Categories Principles Subscale

Like baseline, but for the first time appeared changes in arousal. Changes in eye direction by maintaining eye contact during song presentation as a response to rhythm and melody. Changes in the physical movement of right upper extremity when she played tambourine with the song "She'll Be Coming Round The Mountain" as a response to rhythm. She played keyboard during improvisation as a response to rhythm. Changes in vocalization through singing "She'll Be Coming Round The Mountain" and "He's Got The Whole World In His Hands" as a response to melody and form. Changes in respiration during notes paired to breathing rate as a response to pitch and rhythm. Changes in arousal during initial "Hello Song", after singing paired to breathing rate, then taking out the guitar and singing a capella, therefore as a response to melody and form.

Section 3: Essential Categories Principles Subscale

Vocalization responses were rated with the highest score as she sang all the words to familiar songs. Same as the baseline. She sang "She'll Be Coming Round The Mountain" and "He's Got The Whole World In His Hands". In the first song, she filled in the whole second verse but changed the number of horses to two instead of six, and interestingly, as only two verses were sung, she did mention "we didn't do the whole song".

Non-verbal communication was rated with the highest score as she showed consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. These behaviors were observed during conversation periods, with the use of hand gestures to support verbal communication or to point choices, and during song presentation through interactive eye contact.

Choice-making was rated high as she communicated a preference between 2 objects. Same as the baseline. She chose to prefer the drum compared to the guitar.

Motor skills were rated as high as possible as she showed spontaneous purposeful independent movement through her right upper extremity. Same as the baseline. She played the keyboard with finger dexterity and tapped the tambourine with a wrist movement.

Attention to task was rated high as she attended for the entire session. Like baseline. She was awakened during the initial song and remained actively engaged throughout the session. The tasks were: Hello song (7'), visual tracking (1'15), auditory tracking (2'05"), verbal commands

(40"), song presentation (1'20"), keyboard playing (2'25"), choice-making (45"), closing song (1').

Intentional behavior was rated high as she showed intentional response evident with goals achieved. This based on her ability to make choices, play instruments within musical exchange with the assessor, sing songs, and dialogue with the assessor.

Emotional responses were rated low as no changes in expressive behaviors were seen. Like baseline.

Stimuli 3 - RS

The procedure lasted 30 minutes and consisted of presenting preferred recorded baroque music, songs, and hymns through speakers. Speakers were used considering prior bad experience with participant P2. The music presented was "Toccata and Fugue in D minor" by J.S. Bach, "How Great Thou Art", Haendel The Messiah, "Let Me Call You Sweetheart", "A Bicycle Built For Two", and "Rock Of Ages". The procedure was briefly explained to P4 before starting to listen to music.

The first piece was "Toccata and Fugue in D minor" by J.S. Bach. Before playing the song the researcher told her that they were going to listen to organ music, and he asked her "Do you like organ music?" and she answered, "Well I started playing organ music about a year ago... and I have a daughter that´s been playing the organ". The researcher played the song, and as soon as the music started, she looked at the researcher and said: "that sounds great". After a minute of listening he asked her "Do you know this music?" and she said, "It's familiar but I can´t say I´ve memorized it". When the Fugue started the researcher asked "What about this part, do you recognize it?" and she said "Something like Handel?", and the researcher said "It could be Handel but this is Bach", and she said "This is Bach" pointing to the speaker and nodding her head up and down. The researcher continued "And what is this instrument we are listening to?" and she said "organ". The researcher then asked her "What do you like about organ music?" and she answered, "It's got depth", the researcher followed-up "Do you mean the sound?" and she said, "Yes, the sound".

The second piece was "How Great Thou Art" which was sung by a choir and accompanied by an organ. She looked at the speaker and nodded her head up and down, and spontaneously started singing all the words. The researcher decreased the volume after the chorus and asked her "What is the name of this song?" and she answered saying the lyrics of the chorus "Then sings my soul my savior God to thee". Then, the researcher stopped the song and asked her again "What is this song we just listened to?" and she said "Mendelssohn", and he said "No, it´s not Mendelssohn", and she immediately said "Haendel". The researcher played the song again and asked her to listen carefully and say the name, she listened and answered saying the beginning of the lyrics "Oh Lord my God, when I'm in awesome wonder". The researcher continued asking "Where do you sing this song?" and she said "In our church", and he followed-up "And what is your church?" and she said "It's a Baptist church", he continued "Where is it?" and she said "Upper Michigan", he then asked "Did you have a church in this town? (he named the town)" and she said "Well right here in this building might as well" while pointing with her finger to her right. The researcher continued "Ok, and singing, do you like to sing?" and she answered "Some, in the choir, bigger group", he followed-up "Did you sing in choir?" and she said "Mm-hm" nodding her head up and down, he continued "What was your voice?" and she said "Alto", the researcher asked "Does that mean you have a higher or lower voice?" and she answered "lower". The researcher continued "Were those happy times when you sang in the choir?" and she answered "Definitely... mostly because I could sing with others, and I sang in the high school choir, which included greater music of Handel", the researcher followed-up "In high school? That's cool, did you only sing or you also played?" and she said, "I played piano".

The third piece was the "Hallelujah" from Handel. Before playing it, the researcher said "Now that you have talked about Hendel, I will play some music by him. As soon as the music started, she said "I love that", and spontaneously she started singing all the words of the song. After 1 minute of the music the researcher asked her "Now can you tell me the composer of this piece?" and she said "Haendel again", and he said "Yes, now this is Haendel, what instruments do you hear?", and she said "Hallelujah", and he asked again "Yes, but what instruments do you hear?" and she said "Organ", even though there was no organ he said "ok, what else?" and she remained thinking and then started moving her lips as singing the words. The researcher continued asking "How does this music make you feel?" and she said, "Makes me feel happy", but her face looked like if she was bored. Then, spontaneously she said "I went to a high school where the choir director was into all this kind of music", and he said "Right, while you were alto or soprano?" and she said "alto", and the researcher asked "Did you sing Hallelujah" and she said "Yes", he continued asking "In Michigan right?", and she said "Yes, we were in the border with Wisconsin", then he asked "Is that a cold or warm place?" and she said "About like this", he asked "What is this?" and she said "colder". The researcher followed-up and said "What about the summers, did you have warm summers?" and she said "Well summers were warmer, we could swim and do outdoor things", and he asked "Where?" and she said "Lake Michigan", he said "That sounds like lots of fun" and she said "It was", he continued "Did you go when you were a kid? Did you go as an adult too?", she answered "I started when I was a teen, and then my mother let me keep going with older kids", the researcher continued "And later, did you go with your daughter or husband?", and she answered "Yes, we went to someplace, northern Wisconsin, and it was warm there", he asked "And who was there?" and she said "My daughter, my husband, and myself". The researcher followed-up on this memory and asked "And how old was your daughter by that time?" and she said "Four to six", then he asked "And what about you?", she answered "I wasn't much older, barely older than some of them", he followed-up "But would that be 40, 50, 60?", and she said "Thirty-six". The researcher validated the memories shared by saying "Thank you for sharing with me these memories, I am sure they are an important part of your life, right?", she nodded her head up and down and said "Swimming was something I did if I could... but I wasn´t supposed to swim at all", he asked "Why?", and she said "For being responsible, like whirlpools, things we had to be aware of" she accompanied the world whirlpool with an appropriate fast circular movement of her index finger.

The fourth song was "Let Me Call You Sweetheart" by Bing Crosby. She started singing the first lyrics and then stopped but kept listening. The researcher asked her "So you know this song, do you like it?" and she nodded her head up and down and said "yeah", and she continued singing. After 1 minute the researcher asked her "Do you know the person that is singing?" and she said "I've heard him, but I don't know", the researcher said "I'll give you a clue ok?", and she said "A clue? ok", and he said "His name rhymes with ring", and she said "It's not Haendel", and he continued "Ok, now instead of an R put a B in the word ring", and she said "Bring", he continued "take the letter R out", she said "R out", he said "Bing", and she said "Oh, Bing Crosby", and he said "There you go, give me five!", she followed giving a high five smiling and slightly laughed. Then she said, "I didn't listen to a whole lot of music on recordings, when I got into high school, I was introduced to more of that, our high school teacher wanted us to learn some of that". The researcher asked her "Does this song bring you any memory?", she said, "When I was growing up", he asked, "How old were you when this song was out there?", she said "In Michigan? I was in high school; I don't remember being much above high school". The researcher played the song again, as it was over, and continued asking saying "Ok and how does it make you feel this song, because it is a love song, right?", and she said "Well it gotta be a song, for, sweethearts", the researched laughed, and she smiled and laughed too, then he asked "And who is your sweetheart?", she answered while still smiling "Now or then?", the researcher said "That´s a good question, so now and then you had different sweethearts?", and she answered "Well in high school there was a high school teacher who had some of the young people singing these songs and he was really good" while still smiling, the researcher continued "And who is your sweetheart now?", then she said "Who? You are getting pretty personal", and she smiled bigger, showing her teeth, and laughed louder than the other times, the researcher prompted another high five saying "That was a good answer!" and she followed doing the high five while still smiling.

The fifth song was "A Bicycle Built for Two (Daisy Daisy)" by Nat King Cole. While the researcher was preparing the song, she kept smiling. When the song started, she immediately started singing, louder than usual, and said to the researcher "I learned that in high school, we had a good high school teacher". When she said that she was still smiling, and her words were louder too. The researcher asked her "Is this the music teacher you were telling me about?", and she said, "Gilbert, Gilbert was his last name, and he had a daughter in our class". The researcher continued "Do you have memories with this song?" and she said "Daisy Daisy? I'm half crazy all for the love of you", and he said "Ok, and what about the person that is singing, do you recognize him?", and she nodded her head to the sides like saying no, the researcher said "I'll give you a hint, his last name rhymes with pole", she said "He isn't German, isn't he?" and the researcher said "no", and he continued "his name rhymes with Pat, but starts with an N, his name starts with an N, and rhymes with Pat", and she said "Nat King Cole?". The researcher congratulated her and prompted another high five saying "Yes, wonderful!'", she followed the prompt and smiled and laughed again. The researcher then said to her "I remember you told me a story about the time you saw a bicycle built for two", and she immediately said, "yes, it was down our street" while moving her index finger from left to right and smiling, he said "Tell me more", and she said "Well it was just like a long ride for events, so anything came to town that was worth paying attention to it was usually on our street... and then... I kinda dropped mostly music that was on the street". The researcher refreshed the question "So did you ever saw a bicycle built for two?" and she said "Yes, I had the chance to tried it out once, it was a little bit scary because you don't know what the bicycle will do", then he said "Right that could be scary", and she continued "Yeah, my feet were on the pedals...um... but they would have... patterns through town and passed our house, of different ones riding and doing circus kinds". The researcher continued "Well if the bicycle was built for two, who were you riding with?" and she said, "I don't remember that I was riding with somebody, the bicycle built for two was to take two, and I guess I learned how to ride a bicycle built for two, but I didn't do it as a kind of profession".

The last song was an excerpt from "Rock of Ages" in a choir version. When the song started she sang the words, and after a while, she said: "This is interesting because when I first came into this building, it was the room on the other side over there, and I used to hear some of this music coming through".

To close the researcher said "Well P4. I showed you six songs, what were your favorites?" and she said "Rock of Ages", as she was not answering the researcher asked her "Do you want me to help you refresh your mind?" and she said "Yeah", then he said "Bach, How Great Thou Art", and she said "Oh yes that one, for sure", and he continued saying "Haendel

Allelujah, Let Me Call You Sweetheart, and Daisy Daisy". The researcher asked her, what was favorite then? and she grabbed her head trying to think, the researcher then said "Well, it looks like How Great Thou Art is very special to you, right?" and she agreed with a nod of her head and naming the song back to him. The researcher thanked her for her time and said he also enjoyed sharing the songs with her.

MATADOC After RS

Baseline Responses

P4 showed similar responses at rest observed compared to the first MATADOC.

Pre-observational	**Post-observational**
Talks to/with assessor	Head to front, right, down
Head to front	Talks to/with assessor**
R hand movement (caresses left arm, manipulates strap	R arm/wrist/hand movement (points with a finger, divides a space from left to right, moves like playing guitar with a movement of wrist)
R hand on the right cheek/under the chin	R hand under the chin or touches mouth/cheek.

*: P4: You are pretty good if you can write music in 3 minutes. *(She said this because the assessor told her that they were going to have a short rest of 3 minutes while he would be writing some stuff down).* NE: (laughs) You are right. P4: I learned these kinds of music through a cousin of mine, who was into this type of music. NE: A cousin of you? P4: A cousin. He was from upper Michigan, Gladstone. NE: Do you happen to remember his name? P4: Roger, Roger Olson. NE: So what were you saying about him? P4: He was a cousin that used to like to play and sing, he was the first that got me introduced to some of this music. NE: Was that before high school. P4: That was before high school... He was a musician. NE: What did he play? P4: He played the guitar, and he used to bring it with him all the time, so he would sit there and played the guitar. NE: What songs did he play? P4: Daisy Daisy give me your answer do, I remember

that one... I'm half crazy all for the love of you... It may not be a stylish marriage, and all I can afford is a carriage... and in his case that was probably true, he was not very wealthy. NE: Who was not wealthy? P4: This cousin from my family, Roger Anderson was his name, and he went to school in the Chicago area... I'm trying to remember the name of the school... Anyway, I used to like to listen to him. But, when I was growing up I was not forbidden to listen to this kind of music, but I was encouraged to listen more to hymns. NE: What do you think about that? P4: I think it was good, I prefer hymns to... NE: To more popular music? P4: Yes, to more popular type.

**: P4: Where did you grow up? NE: In Chile. P4: In Chile, which would be different music than we've heard in Gladstone Michigan. NE: Yes, for sure. I grew up listening to a lot of guitar music, but also rock. P4: My cousin who played the guitar up in Crystal Falls, Michigan, got into more of the Chilean methods of playing. NE: Chilean methods? P4: Well they were all different than our American songs would be... (silence) We had a cat at our house. NE: You had a cat? That's sweet. What was its name? P4: Kita. NE: Right you once told me about it, what was color was Kita? P4: Pretty much like the body of the guitar (points at the guitar). NE: Like brownish? P4: Brownish, yeah... but he liked music, and I wasn't quite familiar with the music, I couldn't play the music he liked so well. NE: What was the music that he liked? P4: More of the style of the banjo. NE: Like country music? Like bluegrass? P4: Well, as time went on, he was taught more country... It's interesting when I grew up in this building, this part of the building was rarely used *(she moves her open hand dividing space from side to side),* but they played the music I liked better than any other.

Section 1: Essential Categories Principles Subscale

Responses to visual stimuli. Can focus alternatively on more than 1 visual stimulus. Same as the baseline. She tracked the stimuli in all 4 quadrants. During choice-making and instrument playing she looked at the assessor and instruments alternatively. Same as the baseline. Additionally, she identified the image as an orchestra and identified the violins and cellos.

Responses to auditory stimuli. Consistent localized auditory stimuli played with hand chimes (A3 and D#6) in 8 out of 10 opportunities. Same as the baseline. However, she needed repetition of the question as sometimes appeared unresponsive, she did not always turn, but she did point with her finger successfully.

Awareness of musical stimuli. Showed consistent interactive responses within musical exchange. Like baseline. During song singing, she sang matching pitch and rhythm of the words on "How Great Thou Art" and in "Home on The Range". During guitar playing, she strummed the guitar matching tempo of the song "Home on The Range". On keyboard improvisation, she played following tempo, rhythm, and style but stopped in two times and needed prompts to reinitiate. She finished with the researcher after ritardando.

Responses to verbal commands. Consistently followed verbal commands. Same as the baseline. She followed the following commands "touch the drum", "touch the guitar", "strum the guitar", and "strum all the strings".

Arousal. Aroused throughout the protocol. Same as the baseline. She actively participated during the 25 minutes of the session.

Diagnostic Outcome. Score 10, Higher-level state.

Section 2: Essential Categories Principles Subscale

Like baseline. Changes in facial gestures through smiling after listening to the first verse of "Home on The Range" as a response to the melody. Changes in eye direction by maintaining eye contact during song presentation as a response to rhythm and melody. Changes in the physical movement of right upper extremity when she strummed the guitar to the song "Home on The Range" or played keyboard improvising with the assessor as a response to rhythm, melody, and tempo. Changes in vocalization through singing "How Great Thou Art" and "Home on The Range" as a response to the melody.

Section 3: Essential Categories Principles Subscale

Vocalization responses were rated with the highest score as she sang all the words to familiar songs. Same as the baseline. She sang "Home on The Range" and "How Great Thou Art".

Non-verbal communication was rated with the highest score as she showed consistent use of spontaneous and appropriate social communication gestures. Same as the baseline. These behaviors were observed during dialogue, with the use of hand gestures to support verbal communication, to point choices, and during song presentation and keyboard improvisation through interactive eye contact.

Choice-making was rated high as she communicated a preference between 2 objects. Same as the baseline. She chose to prefer the guitar to the keyboard.

Motor skills were rated as high as possible as she showed spontaneous purposeful independent movement through her right upper extremity. Same as the baseline. She played the keyboard with finger dexterity and strummed the strings of the guitar with a wrist movement.

Attention to task was rated high as she attended for the entire session. Like baseline. She participated actively and fully engaged. The tasks were: Initial song (1'10"), visual tracking (1'30), auditory tracking (3'), verbal commands (1'), song presentation (1'), choice-making (55"), guitar playing (2'05"), keyboard improvisation (2'35"), closing song (1').

Intentional behavior was rated high as she showed intentional response evident with goals achieved. Same as the baseline. This based on her ability to make choices, play instruments within musical exchange with the assessor, sing songs, and dialogue with the assessor.

Emotional responses were rated with the highest score as she showed changes in expressive behaviors related to stimuli on more than one occasion. Different from baseline. These changes were observed in 5 times. The first time was contingent to the conversation where she asked "Where did you grow up?", he said "From Chile", she said "Maybe you've told me that already", and he said "Yes, when we met today, like an hour ago", then she smiled and laughed. The second time she smiled was when she said, "That sounds where I grew up" after listening to the first verse of "Home on The Range". The third time was also contingent on the follow-up conversation about this song. She reminisced about a park where she grew up, where people could see the deers, the assessor asked her "Weren't they scared of humans?", she nodded no and said, "They saw enough of them", then she smiled and laughed. After this, a smile remained on her face for at least a minute, while she kept reminiscing about this story. One more smile with a laugh was shown by her after the assessor asked her "They were beautiful, right?" and she said, "At least the ones that were like Bambi". The fifth expressive behavior was a verbal statement where she said that she "felt good playing all the notes" after the assessor asked how she felt improvising with the keyboard.

APPENDIX F: ACRONYMS USED IN THE STUDY

AD: Alzheimer's Disease

ADL: Activities of Daily Living

ACTIVE: Advanced Cognitive Training for Independent and Vital Elderly

AHRQ: Agency for Healthcare Research and Quantity

AMMT: Associative Mood and Memory Training

ARCD: Age-Related Cognitive Decline

APOE e4: Apolipoprotein E gene

AEP: Auditory Evoked Potentials

BPSD: Behavioral and Psychological Symptoms of Dementia

bvFTD: Behavioral Variance of Frontotemporal Dementia

CATD: Clinical Alzheimer´s-Type of Dementia

CDR: Clinical Dementia Rating scale

CRS-R: Coma Recovery Scale-Revised

DBS: Deep Brain Stimulation

DMN: Default Mode Network

DOC: Disorders of Consciousness

EEG: Electroencephalography

ERP: Evoked Related Potential

fMRI: Functional Magnetic Resonance Imaging

FTD: Frontotemporal Dementia

GCT: Gatos Clinical Test

GCS: Glasgow Comma Scale

GDS: Global Deterioration Scale

GMV: Grey Matter Volume

HRV: Heart Rate Variability

IDMT: Individual Dialogic Music Therapy

IRR: Inter-Rater Reliability

LPA: Logopenic Aphasia

MACT: Musical Attention Control Training

MATADOC: Music Therapy Assessment Tool for Awareness in Disorders of Consciousness

MCI: Mild Cognitive Impairment

MCS: Minimal Conscious State

MEAM: Music-Evoked Autobiographical Memory

MiDAS: Music in Dementia Assessment Scales

MMIP: Musical Mood Induction Procedure

MMN: Mismatch Negativity

MMSE: Mini-Mental State Examination

MSOT: Musical Sensory Orientation Training

MT: Music Therapy

MTED: Music Therapy Engagement scale for Dementia

MT-MSS: Music Therapy Multi-Sensory Stimulation

MTPPPQ: Music Therapy Patient Profile and Preference Questionnaire

NCD: Neurocognitive disorder

NMT: Neurologic Music Therapy

nu_LF: normalized units of Low Frequency

PET: Positron Emission Tomography

PNFA: Progressive Non-Fluent Aphasia

RCT: Randomized Controlled Trial

ROT: Reality Orientation Therapy

RT: Reminiscence Therapy

SD: Semantic Dementia

SMART: Sensory Modality Assessment Technique

SPT: Simulated Presence Therapy

SS: Sensory Stimulation

SSD: Severe Stage of Dementia

TBI: Traumatic Brain Injury

TRR: Test-Retest Reliability

UW: Unintelligible words

VaD: Vascular Dementia

VS: Vegetative State