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## Sound Stimulation in Patients With Alzheimer's Disease

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## Sound Stimulation in Patients With Alzheimer's Disease

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### Disclosure

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**Abstract:** Sound stimulation is an important approach to consider when working with patients with Alzheimer's disease. Both music and other forms of sound stimulation can contribute to improved health and well-being and are often easily implemented in the long-term care (LTC) environment. This paper provides an overview of the two basic approaches to the use of sound with persons in LTC (music therapy and music medicine), as well as a discussion of considerations for implementing various types of sound stimulation in the LTC setting.

**Key words:** Auditory stimulation, Alzheimer's disease, rhythmic sensory stimulation, music therapy, physioacoustic therapy, cell growth, music medicine.

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**Abstract:** Sound stimulation is an important approach to consider when working with patients with Alzheimer's disease. Both music and other forms of sound stimulation can contribute to improved health and well-being and are often easily implemented in the long-term care (LTC) environment. This paper provides an overview of the two basic approaches to the use of sound with persons in LTC (music therapy and music medicine), as well as a discussion of considerations for implementing various types of sound stimulation in the LTC setting.

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Music therapy has newly received some media attention over the past few years. For instance, *melodic intonation therapy*, “a treatment that uses the musical elements of speech (melody and rhythm) to improve expressive language by capitalizing on preserved function (singing) and engaging language-capable regions in the undamaged right hemisphere,”<sup>1</sup> was used to help Congresswoman Gabrielle Giffords regain speech after she was shot in the head in 2011 and was the subject of news coverage at the time.<sup>1</sup> The 2011 movie *The Music Never Stopped* profiled the work of music therapist Dr. Concetta Tomaino and was based on the true story of a patient of Dr. Oliver Sacks. The 2011 book *Sing You Home* by Jodi Picoult focused on the career of a music therapist who works with hospital clients and a suicidal teen. Finally, a flurry of media attention on the use of iPods in long-term care (LTC) was spurred by a viral video excerpted from a movie titled *Alive Inside*.<sup>2</sup> This video features Henry, an LTC facility resident with dementia, who usually sits motionless but suddenly begins moving his arms and legs and “awakening” when he hears a familiar song. This recent attention provides an opportunity to reflect on the types of auditory stimulation—not solely music—that we, as healthcare practitioners, are providing in LTC settings. While listening to music certainly has benefits, a number of factors should be considered when music and auditory stimulation are used as treatment for any patient and in any environment. When used in a deliberate and well-planned manner, taking into account environmental and personal factors, music and sound stimulation may be optimized to promote their therapeutic qualities, contributing positively to a patient’s well-being.

The premise of using sound in connection with health is not new. Music and medicine have been paired throughout history, and music has been used in many cultures around the world in connection with healing practices. For example, a shaman is a musician, medicine man, and priest who uses music in religious rituals to drive out disease. In Greek mythology, Apollo, the god of music and medicine, used music to restore a person to a state of harmony and order, promoting health.

Modern science offers new perspectives and possibilities for sound in healthcare. Although the use of high-frequency ultrasound has long been a part of modern healthcare, the therapeutic value of using low frequency sounds has only recently been recognized in Western medical science.<sup>3</sup> There is no clear definition in the literature for the term *auditory stimulation*, but it could be described simply as the use of sounds to generate an effect on the body or mind. Clifton<sup>4</sup> defined *music* as “the actualization of the possibility of any sound whatever to present to some human being a meaning which he experiences with his body—that is to say, with his mind, his feelings, his senses, his will, and his metabolism.”

This paper provides an overview of various types of sound stimulation to consider in older adults, particularly those with Alzheimer’s disease (AD). Music therapy and music medicine are described with respect to the multiple levels at which sound and music stimulate the body and mind. The paper concludes with a discussion of factors to consider when implementing these types of opportunities for persons in LTC.

### **How Sound and Music Work**

There are currently two basic approaches to the use of sound with patients in LTC: (1) music therapy and (2) music medicine. The differences between the two are not yet clearly established in practice but hinge on the nature of the sound used, the mechanisms assumed to facilitate the effect, and the role of the therapist. Essentially, *music therapy* involves moment-by-moment, client-oriented decision-making by a therapist applying specialized skill to use music as a means to facilitate therapeutic ends. A *music medicine* approach assumes that the sound or music is the basis for an effect on body or brain and, therefore, can be dosed, prescribed, and used with or without a therapist actively engaged during the process.<sup>5</sup>

These two approaches to the use of sound with persons in LTC draw quite distinctively on levels at which sound and music affect us. The following is a four-level model of music response<sup>6</sup>: (1) a learned associative emotional arousal response to melodies and other musical features (eg, that is “our song,” that is patriotic music); (2) the use of cognitive processing channels—involving various neural circuits and components (eg, the auditory system, language processing areas) —to decipher sound stimuli into what we hear as music; (3) rhythmic stimulation of the auditory or somatosensory system to create brainwave entrainment (coherent neural oscillation; eg, how music with a rhythm of

two beats per second can facilitate sleep); and (4) cellular stimulation (eg, increasing circulation in a muscle or causing a brain cell to grow). In a general way, music therapy deals mainly with levels one and two, and music medicine focuses on levels three and four. A brief explanation follows.

### ***Associative and Emotional Responses to Sound and Music***

For most individuals, engagement with music is fostered by some emotional experience with music.<sup>7</sup> Bartel<sup>8</sup> proposed that emotional response and physiological arousal to music is created by an accumulation of learned associations with music unique to each individual. An example of a general association is that, for someone who has grown up in North America, music in a major key is "happy," whereas music in a minor key is "sad." These associations are formed at a young age and are reinforced through media pairings, cultural events, and social interactions.

Music can also arouse emotion by triggering emotional memories once associated with specific music. The amygdala, where emotions and short-term memory are processed, can create a strong link between music and contextual factors, such as an emotional occasion (eg, a wedding or a funeral). Thus, when a person hears particular music, it can trigger the associated emotional memory and arouse the emotions associated with that event. Music can evoke mental, physical, and emotional responses by arousing memory and emotion concurrently. As a result of these effects, music and music therapy interventions have been shown to reduce agitation, wandering, restlessness, aggression, unwanted verbal behaviors, and irritability in persons with AD.<sup>9-12</sup>

### ***Cognitive Processing of Sound and Music***

The perception of music is a broadly distributed brain function, and the task of making music draws on auditory, motor, visual, emotional, structural, and linguistic memories.<sup>13</sup> The areas of the brain activated by music include those involved in auditory perception, motor control, executive functioning, memory, and attention.<sup>14</sup> Music may activate the brain's systems uniquely compared with speech or other stimuli.<sup>15</sup> For example, persons with cognitive impairment engaging in musical activities such as singing can bypass the left hemisphere speech center to produce speech.<sup>16,17</sup> With a growing understanding of the neural channels that are involved in specific music tasks and functions, music is showing promise as a tool for healing the brain.<sup>18</sup>

Further, regions of the brain not linked to auditory processing, including the areas involved with movement, attention, and memory, are activated when a person listens to music. The hippocampus and parahippocampal regions of the brain (areas that are associated with memory function and are damaged in patients with AD) are activated after listening to pleasant music as opposed to unpleasant music, as observed by functional magnetic resonance imaging studies.<sup>19</sup> With respect to cognition, background music has been found to significantly improve cognitive performance in older adults and patients with AD,<sup>20</sup> as well as in undergraduate students,<sup>18</sup> suggesting that this type of stimulation is beneficial for cognition across the life span.

### ***Rhythmic Stimulation of the Auditory or Somatosensory Systems***

One of the fundamental and most easily perceived elements of music is its regularly occurring pulse or beat. Rhythm induces a physical response (eg, tapping of the foot) and thus can be used in therapy as a stimulant. When the brain is stimulated with regular auditory pulses, electrical activity in the brain ("brain waves") entrains (or synchronizes) with the rhythmic pulse. This phenomenon enables music therapists or healthcare providers to structure exposure to music or rhythms to facilitate a number of desired outcomes, including relaxation and sleep. With this principle in mind, music has been composed with specific purposes, such as to assist in sleep or relaxation by targeting the delta or theta brainwaves, respectively. For example, David Bradstreet, a Canadian singer-songwriter, has won awards for his music produced for sleep and stress relief ([www.davidbradstreet.com](http://www.davidbradstreet.com) (<http://www.davidbradstreet.com>)).

**Entrainment of movement.** Mentally trackable beats in music (pulses with a rate slower than approximately three per second) can be used to address and enhance motor control through the process of auditory-motor entrainment. This neurologic technique is known as *rhythm auditory stimulation* and is commonly used to assist in motor movement in an immediate context or in physical rehabilitation to recover functional gait patterns in adults with various diagnoses.<sup>13</sup> When exposed to music with a beat faster than three pulses per second, human attention fatigues quickly and resorts to tracking the grouping pulse.

**Entrainment of brain states.** Neural activity commonly associated with certain cognitive states include the following:

- Delta wave (1-4 Hz; sleep state)
- Theta wave (4-7 Hz; deeply relaxed, semi-awake, almost trance-like state)
- Alpha wave (8-12 Hz; awake and relaxed state)
- Beta wave (12-20 Hz; alert or active thinking state)
- High beta wave (20-27 Hz; stressed and anxious state)

Less understood, but currently the focus of considerable research, is gamma wave activity (27-100 Hz). Of greatest interest is 40-Hz brain wave activity, because 40 Hz appears to be a fundamental frequency of intra-brain communication and, consequently, a covariate of cognition.<sup>21</sup>

**Driving gamma.** Because the oscillatory frequency of neural activity described as gamma waves is within the frequency range of audible low-pitched music, low-frequency sound can drive a neural response and can contribute to increased neural rhythmic oscillatory coherence.<sup>22</sup> *Rhythmic sensory stimulation* (RSS) is the stimulation of neural activity with sound applied rhythmically to the body or auditory system. What is important to note for LTC professionals is that persons with AD have lower levels of 40-Hz brain activity, and RSS can drive an increase in 40-Hz brain activity.<sup>23</sup> There is currently considerable interest and research effort focused on the use of RSS as a treatment for neuropathic pain, AD, Parkinson's disease, depression, and tinnitus.<sup>6,24</sup>

### **Sound and Music as Cellular Stimulants**

Sound is a physical mechanical vibration and, as such, can exert a stimulative effect on cells, which can result in improved mobility,<sup>25</sup> increased circulation,<sup>26</sup> decreased low-density lipoprotein and blood pressure,<sup>24</sup> decreased pain,<sup>27</sup> and reduced muscle strain and stiffness.<sup>28</sup> Cell-level responses are the basis of *low-frequency sound stimulation* (LFSS; also known as *vibroacoustic therapy*, *physioacoustic therapy*, or *sound wave therapy*), a process of applying low-frequency stimulation to the body.<sup>6,29</sup> LFSS is typically accomplished with a device such as a chair or a bed fitted with special speakers to generate a sympathetic resonance in a target group of cells in the body. By affecting nerve tissue, muscle, and connective tissue, and by improving blood and lymph circulation, this therapeutic stimulation can promote psychologic and physical well-being, including decreased agitation, improved range of motion, and improved sleep patterns.<sup>3</sup>

Several studies are showing real promise for the use of sound vibration as a treatment for conditions of aging, namely brain cell deterioration and bone density deterioration. Koike and colleagues,<sup>30</sup> for instance, found that low-frequency stimulation of 10–100 Hz induced enhancement of neurite outgrowth and, most importantly, that the effect of 40-Hz stimulation was approximately three times greater than that of nerve growth factor alone. The implication is that LFSS may slow the loss of brain cells.

### **Music Therapy**

*Music therapy* is the specialized use of music, sound, and sound properties to increase physical, cognitive, socioemotional, and spiritual well-being. It is facilitated through the client–therapist relationship by a music therapist trained to assess and implement a treatment plan according to the client's needs.<sup>31</sup> In music therapy, clinical music-based interventions are facilitated with both live and recorded music, with the music therapist examining their effects on such parameters as stress and pain.<sup>32,33</sup>

While working with all populations, music therapists conduct regular assessments to establish a baseline and set goals and objectives for the treatment plan. Persons with AD require individualized treatment plans that change over time to meet their needs. Music therapy goals can be conceptualized in a variety of domains, including physical, cognitive, communicative, emotional, social, and spiritual. Examples of these goals for persons with AD include the following:

- Maintaining and/or stimulating cognitive skills

- Maintaining connection to one's identity and sense of self
- Fostering social interaction and decreasing isolation
- Improving and/or maintaining fine and gross motor skills
- Decreasing challenging behaviors (eg, agitation, wandering)
- Decreasing anxiety and/or increasing feelings of relaxation and well-being
- Improving mood and/or increasing motivation

Although patients with AD face many neurologic deficits, the areas of the brain responsible for music processing and production are often preserved in such individuals, making music an appropriate "access tool" to engage mental processes and connect to the inner self. Music therapy interventions are also broad-ranging and exist on a continuum, from passive to active techniques. Some examples of such interventions include singing and/or vocalizing music without words, moving to music and/or dancing, playing instruments, discussion, life review, and reminiscence. *Discussion* often arises from musical interactions and can be sparked by the therapist asking simple directed questions about the topic of the song, or through more specific reminiscence questions. At times, singing songs often prompts spontaneous reminiscence in persons with AD, and discussion of lyrics is also common. To further assist with reminiscence, a therapist may have specific questions he or she asks or may add additional sources of stimulation, such as props (eg, photos, objects). Life review involves looking back on a person's life and celebrating accomplishments, acknowledging significant events, moments, and even regrets. Songs can be chosen to represent these memories, or songs can be used to spark storytelling.

### ***Long-Term Benefits of Music Therapy in Persons With AD***

*Responsive behavior* is a term used to describe the behaviors that a person exhibits in response to something that is present in—or perhaps missing from—his or her environment, causing him or her to react to it. Examples of undesirable responsive behaviors include wandering, restlessness, and agitation. Various studies have demonstrated that music therapy can decrease undesirable responsive behaviors during and immediately after a music therapy session.<sup>9,11,12,34</sup> In a 2002 study that measured the agitation of individuals with AD, agitated behaviors were found to decrease 45 minutes after a music therapy session as compared with scores 1 week prior to treatment.<sup>11</sup> Music therapy was most effective in reducing verbally disruptive behaviors, such as swearing or yelling, and restless behaviors rather than physical agitation. There is currently limited research regarding any long-term benefits of music therapy. The case vignette provides an illustrative example.

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### **Case Vignette**

Jack is an 84-year-old LTC facility resident with an AD diagnosis. His condition is advanced, and he experiences severe anxiety, memory deficits, and behavioral changes. He often paces around his room and calls out to everyone who walks by his door, asking if they can help him "get home." During his weekly 45-minute music therapy sessions, however, which include a variety of musical activities such as singing, moving to music, improvisation, reminiscence, and songwriting, Jack is able to sit for the entire session and participate actively by singing songs and moving to the music. He is also able to recall through singing "My Favorite Things," which was featured in the movie *The Sound of Music*. This is quite remarkable considering that he often does not recall the name of his wife, who visits him daily. In music therapy, he does not wander and he does not call out. He socializes and interacts with others in the group, and he laughs and smiles frequently. The patient's anxiety seems to have disappeared.

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### **Practical Ways to Use Music With Patients With AD**

Music can also be used in the LTC setting in situations facilitated by individuals who are not trained music therapists (eg, entertainers, caregivers). Musical experiences exist along a continuum, ranging from passive to active. Both background music and recreational music, for instance, have demonstrated numerous benefits in the LTC population.

## **Background Music**

*Background music*, also known as environmental music, is music "of any kind that is played while some other activity is going on, so that people do not actively attend to it."<sup>35</sup> The study of background music focuses on the influence of music on nonmusical behaviors.<sup>36</sup> Background music played in hospital, LTC, and other healthcare settings serves to reduce environmental noise and to distract and calm patients and their families during an otherwise stressful experience. Playing soothing music in a waiting room may facilitate relaxation while suggesting that time has passed quickly. Increasingly, surgical patients are being allowed to select music to play in waiting rooms prior to their procedures in order to calm and distract them.<sup>37</sup> In LTC settings, nurses could play background music while providing care (eg, dressing, bathing, toileting, feeding) to patients with AD. This music may make the experience less challenging for residents, particularly those who display symptoms of anxiety or agitation when care is being provided. In fact, the music may also improve the nurse's experience.

Although background music has a powerful influence on human behavior and cognition, it may not be as effective in the aging population. Individuals as young as in their 40s may start experiencing a gradual decline in high-frequency hearing, called *presbycusis*, which may result in them having greater difficulty attending to stimuli in the presence of environmental music or noise.<sup>38</sup> With this in mind, it is important for healthcare providers to critically assess any environment in which background music is added.

## **Recreational Music**

Music that is used or made in a recreational setting, such as a concert, listening to an iPod, or a group sing-along, can address an individual's emotional and social needs.<sup>27,39,40</sup> For instance, studies have demonstrated that musical exposure increased levels of immunoglobulin A (an antibody associated with overall good health) and decreased levels of cortisol (a hormone shown to be released with higher levels of stress), thereby increasing the patient's level of relaxation.<sup>28,41-43</sup> Furthermore, listening to music may provide reprieve from, and, consequently, help decrease the perception of, acute or chronic pain.<sup>44-46</sup> Participants of social music-making activities have also reported experiencing benefits, such as increased support and decreased loneliness.<sup>47-49</sup>

An important distinction between recreational music and music therapy is that music therapy is facilitated by a trained music therapist, who addresses underlying causes of the patient's health issue and facilitates therapy according to a treatment plan. There are benefits of recreational music, however, including its cost-effectiveness and the fact that it can be used to engage large groups of people at a time or to provide enrichment for an individual when specialized attention may not be possible. Recorded music can be used in a variety of settings to decrease agitated behaviors; in fact, several studies explored the use of CDs personalized to the residents' musical preferences for enrichment and to calm those with agitation.<sup>50-52</sup> Music used during mealtimes also decreased nonaggressive agitated behaviors, such as wandering and yelling.<sup>53-56</sup>

Music also has a positive effect on patient-caregiver interactions, especially concerning patients with severe AD. Clark and colleagues<sup>57</sup> found that playing recorded music while bathing residents with severe levels of cognitive impairment may help to decrease aggressive behaviors and can turn the chore into a more pleasant experience for both the resident and the caregiver. Götell and colleagues<sup>58</sup> reported that the use of background music during care resulted in the patient's increased understanding of the situation despite decreased verbal instruction and narration by the caregiver; this increase in understanding became even more enhanced during caregiver singing, despite an even greater decrease in verbal communication by the caregiver. Hammar and colleagues<sup>59</sup> reported similar findings in their 2011 study in which *music therapeutic caregiving* (MTC, when caregivers sing for, or together with, patients with dementia during care situations) significantly decreased negative emotions and care-resistant behaviors, such as pulling away, grabbing objects, and adduction, and increased positive behaviors, such as the expression of positive emotions and increased alertness. Another study conducted by Hammar and colleagues<sup>60</sup> revealed that caregivers providing MTC reported enhanced communication between themselves and the patient, as well as greater appropriate expression from the patient.

## **Considerations for Music and Auditory Stimulation Programs for Patients With AD**

Factors that should be taken into consideration when deciding on the optimal type of auditory stimulation in an LTC setting include the needs of the resident(s), the environmental climate, and the resources available, such as staffing and general cost constraints. Various types of stimulation are often designed to target specific behaviors or needs that a resident may have, such as a group sing-along to build a sense of community or traditional music therapy to improve an individual's cognition, agitation, and anxiety. A particular need may often be addressed in multiple ways; in these situations, the various options for stimulation can be narrowed down based on their fit among environmental factors and resources available, keeping in mind that several interventions can also be used in tandem to optimize treatment.

### ***Resources***

Different interventions will require different levels of operation. Some equipment, such as the Next Wave® Physioacoustic chair and other LFSS therapy devices, will require specialized training to operate and set-up and are, therefore, not possible for some LTC facilities with limited resources. Relaxation goals and pain relief may also be addressed through the use of more common devices, such as CD players and iPods, or by a music therapist. Further, some resources need only to be set-up prior to use (eg, sound system, digital piano), while other equipment may also need to be put away after use, depending on its function, requiring more staff and storage space.

### **Cost**

Although certain technologies, such as LFSS devices and sound systems, may be effective, they can also be high in cost. Mobile devices, such as CD players, however, are versatile and can be used in different locations, including common rooms, hallways, patient rooms, and bathrooms. Free and simple interventions, such as caregiver singing, can be highly effective, either during resident care or in music groups, although not all caregivers may be comfortable singing. The upfront costs of sing-along or music-making groups (eg, for purchasing instruments) are fairly low, and they require minimal costs to maintain with proper instrument maintenance. Also, the use of sleep CDs or personal playlists may provide a benefit to the patient at a low cost, and they are also easily adaptable to personal devices, such as iPods. Individual music therapy sessions have the ability to address specific or more severe behaviors and health issues, but they are less cost-effective than interventions that may apply to larger groups (eg, group music therapy, recreational music activities, background music).

### ***Environmental Considerations***

When considering environmental factors, the healthcare provider may evaluate the following: (1) the presence of background noise (including visual and olfactory stimuli) to decide whether added stimulation may be overwhelming or enriching for the resident with AD as well as other residents in the facility; and (2) the amount of space needed and available to provide the specific type of intervention. For instance, if music is being used to decrease a resident's agitation in a busy environment, the healthcare provider may opt to provide him or her with an iPod, which helps cancel external factors that may be a source of agitation, but also does not further pollute the sound environment for others. iPods may be particularly helpful when used in rooms that are shared by multiple residents. Entrainment sounds for residents with sleep difficulties could also potentially be transferred to an iPod, thus providing the resident with a sleep intervention while allowing his or her roommate to sleep in silence. Further, equipment that requires a lot of space and set-up or a specialized staff may not always be viable, as they are both high in cost and may not be well-received by vulnerable patients.

### **Conclusion**

With the increasing emphasis on nonpharmacological means of controlling the negative effects of AD and improving quality of life for residents with AD, healthcare practitioners in LTC should consider the use of various types of music and sound stimulation. The two basic approaches of using sound with persons in LTC—music therapy and music medicine—have been shown to have numerous physical, cognitive, communication, emotional, and social benefits in patients with AD. The use of background and recreational music can also be helpful for patients with AD, and can be facilitated by therapists who do not have a music background.

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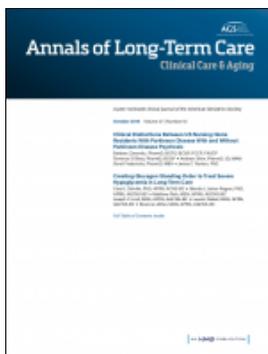
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