Review Article

The Role of Music Therapy in Facilitating Episodic Memory Recall in Alzheimer's Disease Patients: A Review

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ABSTRACT

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that impairs cognitive functions such as memory. AD is the most common form of dementia among older adults, and scientists continue to search for the exact cause of this disorder. Recent research suggests that music has the potential to facilitate memory recall for AD patients, especially when music stimulates emotionally-connected memories. One method used to enhance memory recall is music therapy (MT), in which patients listen to music that stimulates their emotions and facilitates recall of emotion-associated episodic memories. Studies have also shown links between self-selected music and an increased frequency of the use of emotional words during memory recall. Moreover, neuroimaging studies on music and emotion suggest changes in activity in the anterior hippocampal formation, a brain area involved in music-evoked emotions that plays an important role in emotions, behavior, and recollection of past experiences. Through a review of existing literature and empirical studies, this paper explores how familiar music can stimulate recall of emotionally-connected episodic memories in AD patients. The findings of this paper can highlight MT as a useful and accessible tool that could assist AD patients with recall of autobiographical and episodic memories. The reason for this review is to examine MT's ability to potentially enhance the quality of life for individuals with AD.

Keywords: Alzheimer's Disease; Music Therapy; Memory; Neuroscience; Behavioral & Social Sciences

INTRODUCTION

The human brain has the capacity to encode, store, and retrieve various types of memories, including short-term, long-term, and sensory memories. Among these, episodic memory—a form of long-term memory responsible for recalling personal experiences—plays a crucial role in shaping our sense of self. Memories serve many critical human functions, such as learning, adaptation, identity formation, and emotional regulation. Memory allows people to retain information and skills based on past knowledge, which is essential for development (1). Specifically, prior experiences can shape one's ability to make decisions and solve problems (2). Furthermore, memory helps people develop their personal identity by allowing individuals to build their self-perception based on recollection of past relationships and experiences (3). Lastly, the recollection of emotional experiences influences one's future behaviors by establishing a sense of guidance. For example, if someone recalls feeling

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anxious after a poor decision or joyful after achieving a goal, those emotional memories serve as a guide for future actions. These decisions can help individuals avoid repeating mistakes or seek similar outcomes. Therefore, memory has a strong influence on a person's ability to regulate their emotions and behaviors in daily life (4).

However, in individuals with AD, a progressive neurodegenerative disorder, episodic memory is among the first cognitive functions to deteriorate. Individuals with AD frequently experience difficulties in retaining information, acquiring new skills, and recalling past experiences which significantly impair their capacity to adapt and function effectively (5). In addition, AD is the most common form of dementia in older adults and affects not only memory but also language, reasoning, and emotional regulation as the disease progresses (6).

Therapeutic interventions that can alleviate symptoms of AD are gaining attention. Music Therapy (MT) has emerged as a promising approach, particularly in addressing memory loss. Recent studies suggest that familiar, emotionally significant music can stimulate the recall of autobiographical and episodic memories in AD patients. This paper explores the effects of MT on episodic memory retrieval, with a focus on how music-evoked emotions can enhance memory recall. By examining existing research, this study highlights the potential MT holds as a tool to improve the quality of life for individuals with AD (7).

THE BRAIN AND MEMORY

The human brain is a complex organ responsible for various cognitive processes including memory (8). Memory is the continuous process of retaining information over time, and memories can contribute greatly to a person's characteristics, behaviors, motivations, and more (9,10). The brain relies on a network of interconnected brain regions that play distinct roles in memory, including the hippocampus, amygdala, prefrontal cortex, cerebellum, and parietal and temporal lobes. The hippocampus is essential for encoding and combining memories, particularly in converting short-term memories into long-term memories. The hippocampus is also crucial for the formation of spatial and declarative memory, which consists of memory of one's environment and conscious recall of facts, respectively (11,12). The amygdala is involved in the emotional enhancement of memory as it associates emotions with memories, especially those involving fear or pleasure. Therefore, the amygdala allows people to establish lasting memories of emotional experiences (4). Playing a key role in working memory and decision-making, the prefrontal cortex is particularly involved in planning and organizing based on past experiences (2). Rather than serving as a storage site for memories, the prefrontal cortex draws on stored memories from other brain regions such as the hippocampus and combines them with current sensory input. This integration allows individuals to use past knowledge to make informed decisions, adapt to new situations, and plan future actions effectively (13). In addition, the cerebellum contributes to cognitive processes such as neurocognitive development, language skills, and executive function. It is also involved in procedural memory and learning motor skills, such as riding a bike or playing an instrument (14). Finally, the parietal and temporal lobes are crucial for sensory and semantic memory storage to support the consolidation of sensory experiences and factual knowledge (15). The temporal lobe, particularly the olfactory cortex, is integral to processing information related to the sense of smell. This region's close association with the amygdala and hippocampus facilitates the strong link between scents and memories (16). These regions are where certain smells can vividly evoke past experiences (17).

In addition to the various brain regions involved, multiple forms of encoding add to the complexity of memory. For instance, types of memories can be split into two major categories: short-term and long-term memory. Short-term memory (STM), also referred to as working memory, temporarily holds information for immediate tasks, such as remembering a person's name shortly after introduction (1). On the other hand, long-term memory (LTM) stores information more permanently and is categorized into explicit memory and implicit memory (14). Explicit memory includes memories of facts and events, including episodic and semantic memory. Episodic memory refers to personal experiences and specific events, while semantic memory retains general knowledge, facts, and language-based memories (15,18). For example, explicit memory includes the memory of a family vacation, and semantic memory involves remembering the capital of the United States of America. Implicit memory is the unconscious memory of information not intentionally stored in the brain, such as how to ride a bike (19,20). Once learned, this skill does not necessarily require conscious thought or intentional recall (21).

AD PROGRESSION AND MEMORY

AD is characterized by numerous pathological features, including amyloid plaques, tau tangles, and neuronal death, leading to cognitive decline (22,23). In understanding AD progression, the amyloid cascade hypothesis (ACH) has dominated AD research, drug discovery, and clinical trial studies since 1992 (23). The ACH argues that amyloid-beta (Aβ) protein is the primary factor driving AD progression by initiating a sequence of molecular events leading to amyloid plaques, tau tangles, and neuronal death. The Aβ peptide is a 40- to 42-amino-acid fragment generated from amyloid precursor protein (APP) (24). Increased Aβ protein fragments clump together and form extracellular amyloid plaques, which can accumulate and impact neuronal function. This direct involvement in cellular dysfunction contributes to the progressive cognitive decline seen in AD (25).

The initial accumulation of Aβ during the early preclinical stage of AD first appears in the neocortex, a region responsible for cognition, language, sensory perception, and spatial reasoning (26,27). Additional Aβ accumulation occurs in other brain regions during later clinical stages, including the allocortical regions, midbrain, brain stem, and cerebellum (28). Meanwhile, Aβ continues to accumulate in the neocortex (29). In the hippocampus and entorhinal cortex – areas critical for short-term memory and its transfer to LTM – Aβ plaques disrupt synaptic transmission by impairing synaptic plasticity, which is essential for learning and memory (30). These plaques also induce neuroinflammation, leading to the release of cytokines and other neurotoxic factors that further damage neurons and their connections (31). Furthermore, the ACH also states that amyloid plaques induce tau proteins to become defunctive and tangle into hyperphosphorylated tau tangles inside neurons (32). Tau tangles are generally first seen in the entorhinal cortex and the hippocampus, regions responsible for short-term memory and for transfer to LTM (32). Therefore, tau tangles present in the hippocampus could prevent the encoding of LTM and contribute to cognitive decline as a result of impaired memory in AD.

As AD progresses, cognitive decline and memory continue to worsen (33). Typically, to enhance retrieval of episodic memory, the brain activates dopaminergic pathways, which play a crucial role in the regulation of brain regions that support motor, cognitive, and motivational behaviors. Research has shown that the dopaminergic system is responsible for enhancing late consolidation of episodic memory, the process by which a temporary memory is converted into a more stable and longer-lasting memory. However, in AD, the function of the dopaminergic system declines due to decreased dopamine levels, reduced receptor expression, and degeneration of related neurons as the disease progresses, leading to symptoms such as cognitive decline (34,35). This disruption in the dopaminergic system may directly contribute to memory impairments seen in AD patients by weakening the neural pathways essential for encoding, retrieving, and storing information. However, despite the severe cognitive impairments and shortfalls in episodic memory, musical memory is partially spared (36).

Musical memory is the ability to remember music-related information such as songs, melodies, or rhythms and is said to be spared because of the involvement of unique neural pathways in processing music (37). Research also indicates that music engages multiple brain regions involved in emotion and memory such as the hippocampus and amygdala, which seem to be spared more than others in cognitive decline (36). The hippocampus is one of the brain regions affected in the early stages of AD, as it shows rapid loss of tissue and disconnection with other brain parts (38). Additionally, music establishes a strong emotional connection, which makes it easier for AD patients to recall musical memories compared to other types. Therefore, it is possible to utilize music in therapeutic practices to enhance memory and emotional connections in AD patients. For example, the patient listens to nostalgic or reminiscent music in order to facilitate recall of past memories that are connected to these emotions. Research shows that music can evoke strong emotions and facilitate the recall of autobiographical memories in AD patients, offering a meaningful way to connect with others emotionally as well as assist in day-to-day life against typical memory loss in AD (39). Additionally, studies have shown that music intervention can decrease agitation and improve communication in individuals with AD (40). This emotional engagement through music may help in the interim to assist with improved memory or mitigate cognitive decline in AD patients.

MUSIC THERAPY

MT is a recent non-pharmacological treatment that uses music to improve people's quality of life by reducing stress and addressing various aspects of well-being, such as mental, emotional, physical, social, and cognitive qualities (41). MT can involve a number of methods and/or applications, such as playing an instrument, singing, clapping, and dancing, as well as just passively listening to music (42).

Some common uses of MT include mental health treatment and pain management. MT is traditionally used in psychiatric settings to support people who have emotional, developmental, and psychological disorders, such as depression and anxiety by helping patients relax, ease stress levels, and regulate mood (41). Pre-recorded music has also been used while treating cancer patients, which has the potential to reduce their anxiety and pain. Finally, a study conducted at North Sichuan Medical College shows that MT in children with developmental disorders including autism spectrum disorder (ASD) can result in enhanced language communication skills and social interactions (43).

In the field of neurodegeneration, MT continues to be explored for its potential to regulate emotions, reduce stress, and encourage social engagement. Since neurodegenerative diseases currently lack a cure, treatment options typically focus on symptom management and improving quality of life. As MT currently benefits individuals with mental health and developmental disorders, MT has the potential to improve quality of life and support cognitive and emotional functions in patients with AD.

One interesting factor involved in the use of MT treatment in AD patients is the role of preferred music. Music preferences are deeply personal and shaped by factors like age, culture, and past experiences. Therefore, personalized music playlists can effectively impact a person's emotions by evoking strong responses due to their connection to significant life events. A literature review showed that individualized music playlists provided the best cognitive and behavioral outcomes for patients with AD, regardless of the music intervention approaches such as using familiar and mood-associated music (44-47). Adapting music to individual preferences not only enhances engagement but also can stimulate personal memories and emotions, which can significantly improve cognitive function, leading to better episodic memory retrieval. As MT methods continue to develop to aid the recall of episodic memories in AD patients, preferred music provides a new perspective using a personalized approach to benefit cognitive and behavioral function.

EMOTION-EVOKED MEMORY AND MUSIC

Emotions enhance memory processes, and music can evoke a wide range of psychological responses, activating emotional, mnemonic, attentional, and imagery-related processes (48). These psychological functions are located in a distributed, overlapping brain network, highlighting the complexity and intersectionality of interrelationships between emotions, memory processes, and music (48). Studies show that emotional memories are more easily recalled than those without an emotional component, underscoring the fundamental role emotions play in memory processing (49).

Music can activate a broad network in the brain rather than a single designated "music area." Therefore, when listening to familiar music, musical memory retrieval involves areas both within and outside of the temporal lobes, including frontal and parietal regions. The wide range of involvement of music highlights the complexity and intricate nature of musical memory processing. This suggests that music is closely linked to cognitive functions and can engage emotional processing.

Moreover, listening to a favorite song alters the connectivity between auditory brain areas and the hippocampus. When listening to a favorite song or music, the hippocampi were functionally separated from the auditory cortex, suggesting that the brain retrieves, rather than encodes, autobiographical and episodic memories from other brain regions such as the medial prefrontal cortex (mPFC) (50).

Just as there are various genres in music, one can feel different emotions in response to it. Research has shown that emotional music – especially sad music for remote memories, which are recollections from the distant past – was found most effective in recall of autobiographical experience (51). This type of memory refers to the recollection of specific personal events or experiences from one's own life (52). Interestingly, listening to sad music has also been linked to positive emotions and pleasure if the sadness conveyed falls under one of three categories: when it is perceived as non-threatening, is aesthetically pleasing, or plays a role in mood regulation and increases empathic feelings, all which are a result of past experiences. The category of mood regulation and empathic feelings relates to memory, as it talks about how the emotion of sadness has a possible connection to the reflection of the experiences of past events. Another potential explanation for why listening to sad music is effective for recalling autobiographical memories could be its association with nostalgia. Studies have shown that nostalgic experiences can be triggered by sensory inputs, such as music, which encourages the individual to remember past emotions and experiences linked to these sensory inputs (53,54).

DOPAMINE RELEASE AND NEUROPLASTICITY IN MT

MT has the capacity to produce a range of positive cognitive and behavioral outcomes. In addition to promoting general well-being, research has shown that certain biological processes are altered as a result of MT. For instance, a study at McGill University using PET and fMRI brain imaging demonstrated that listening to music induces dopamine release (55). Dopamine is a neurotransmitter, and its release is associated with feelings of pleasure and reinforcement of behaviors (47). This release occurs in specific brain regions, including the nucleus accumbens and ventral tegmental area, which are integral to processing rewards and motivation (53). Dopamine is often referred to as the "feel-good" molecule due to its key role in reward, pleasure, and motivation. As previously mentioned, dopamine is crucial in memory, as it helps signal when an action is pleasurable or beneficial, which encourages the behavior to be repeated (56,57). This process plays an essential role in learning and memory consolidation, further highlighting dopamine's importance in both cognitive and emotional functions (58).

As demonstrated, dopaminergic release plays a crucial role in cognitive enhancement, particularly through mechanisms related to motivation, reward, and emotional regulation (56). Interestingly, MT has the potential to counteract the decline of the dopaminergic system by boosting dopamine levels. This stimulation of dopamine triggers a sense of pleasure and engagement that may mitigate some of the cognitive deficits associated with AD (59). By incorporating the ability of music to evoke positive emotional responses, MT can create more favorable circumstances for episodic memory retrieval (39).

Additionally, when dopamine release is paired with the recall of a specific memory, this behavior will likely be repeated. Studies have investigated how MT is effective in linking music with emotions such as pleasure, as music can trigger dopamine release in the brain's reward pathways, specifically during moments of peak emotional response (57). Another study used fMRI to examine how music activates brain regions associated with emotional processing, highlighting the role of music in inducing pleasurable emotions (60). When listening to pleasant music, the brain releases dopamine, which explains the therapeutic effect of listening to music on mood regulation and lowered anxiety levels (61). The emotional and cognitive benefits of MT therefore arise from the activation of complex neural networks in the brain to enhance connectivity between brain regions, release dopamine, and promote neuroplasticity during activities like listening, performing, or creating music (62-64).

Neuroplasticity refers to the brain's ability to change or adapt by forming, strengthening, or connecting neural pathways based on learning, experience, or recovery needs (65). The development of neuroimaging technology such as PET and fMRI has provided evidence of musically-induced neuroplasticity. For example, the sensory cortices of pianists and violinists exhibit increased activation and reorganization due to the repeated use of the brain regions activated by musical learning (66). MT could therefore be highly effective for patients with neurological disorders due to its ability to alter neural activity and stimulate neuroplasticity (61). For example, MT can help activate brain regions involved in motor control and speech, which fosters the enhancement and recovery of weakened or lost neural connections (67). In a similar manner, MT can stimulate areas of the brain related to emotion and memory, further engaging patients to reduce anxiety, improve mood, and boost cognitive abilities through MT (68).

TECHNOLOGY IN MT

Music and technology share a complementary relationship, evolving together to create new possibilities for expression and innovation. While traditional live instruments remain central to MT, advancements in digital technology have expanded the scope of how music can be created, accessed, and experienced. Furthermore, developments in brain and neuroscience technology have deepened our understanding of how music affects the brain. Tools like brain-computer interfaces (BCIs), neurofeedback systems, and imaging technologies now allow MT to tap directly into neural activity, creating personalized interventions and transformative applications (69).

Technology has the potential to enhance and expand MT by offering new tools for accessibility and creative expression, enabling more therapeutic processes for individuals with neurological disorders (70-72). The Brain Computing Music Interface (BCMI) system is a neurofeedback technology that maps neural signals from the brain to create music (73). BCMI allows users to control music using brainwave signals detected by sensors, typically via EEG. This technology translates these signals into musical notes by analyzing brain activity related to emotion and enables creative expression for individuals with disabilities (74). Additionally, Voice Output Communication Aids (VOCAs) are devices or software tools that help individuals with speech or language impairments communicate. The technology allows individuals to "speak" by selecting words or phrases, so it provides users with a means to express themselves emotionally (75). VOCA can help patients gain access to MT because it will allow for more communication, expression, and participation. By integrating tools like BCMI and VOCA into MT, these innovations increase inclusivity, reach a broader audience, and empower individuals to participate despite physical, cognitive, or communicative barriers (76). This is particularly valuable for individuals with conditions such as dementia, where communication and social skills are often compromised (77). Such advancements have the potential to offer more people the opportunity to experience the benefits of MT and foster meaningful connections through music.

However, it is important to consider the technical constraints that may hinder the widespread adoption of BCMI technology. One major challenge is accessibility, as the high costs and complexity of the BCMI system may limit its availability to the larger public. Currently, the BCMI systems are available in the laboratory setting, so researchers can develop cost-effective versions in order to increase the scope of potential users of this technology (78-81). Additionally, healthcare providers who lack familiarity with AI-driven BCMI applications may be hesitant to integrate them into clinical practice, leading to resistance to adoption in the general field of public health. The most prominent concerns regarding BCMI include data security, safety, and ethical considerations. As BCMI advances, opportunities for cyber security threats raise concerns regarding the possibility for attackers to alter components of the BCMI, which can harm the target subject (82,83). Safety can be another technical limitation specifically for the invasive BCMI systems, which are implanted into brain tissue. Therefore, invasive systems can damage nerve cells and blood vessels, so a comprehensive understanding of human body function and its interaction with foreign elements is necessary to ensure full safety for the patients. Finally, ethical questions about personal security, safety, and accessibility contribute to the lack of widespread access to BCMI as well as the hesitant approach to utilize this technology from numerous healthcare providers (84).

Another technology that explores the integration of music-based interventions is gamma-frequency stimulation. This method involves using auditory or sensory stimuli at frequencies associated with neural oscillations linked to cognition and memory. Gamma-frequency stimulation has shown potential for enhancing brain plasticity and improving cognitive functions, particularly in aging populations (85). When combined with MT, this method could amplify the therapeutic effects by leveraging music's emotional and memory-triggering properties alongside the cognitive benefits of gamma stimulation. This approach highlights a novel intersection of neuroscience and MT, offering promising implications for healthy aging and neurodegenerative disease management.

The use of artificial intelligence (AI) is another interesting development, as researchers are now investigating how it can be used to personalize MT interventions based on patient preferences. One application of AI in MT involves creating AI-driven playlists tailored to the patient's musical tastes, which can enhance emotional engagement and therapeutic outcomes (86). Some AI projects involve turning brainwave patterns into music, which allows for an MT experience tailored to the patient's emotions (87).

MT can significantly improve outcomes in a variety of disorders, such as neurological, psychiatric, and developmental conditions (42). Given the profound impact music can have on the brain, from enhancing cognitive function to improving emotional regulation, MT should be further investigated and considered as a valuable therapeutic approach.

MT AND AD

MT has emerged as a promising intervention for AD, aimed at improving episodic memory recall as well as cognitive and behavioral outcomes in patients. MT is increasingly recognized for its ability to trigger strong emotions, which can help recall autobiographical memories (39). The use of MT for AD is recommended with familiar music, as it strongly influences emotional responses (88). MT interventions can range from passive music listening to active engagement by creating music (89). In addition, reducing anxiety and agitation when listening to music could improve attention during encoding, which allows for enhanced memory performance (90). By calming stress, MT creates a conducive environment for better memory performance in AD patients. Memory is closely tied to emotions and stress levels, and MT not only stimulates emotional recall through familiar tunes but also reduces stress that may hinder memory processing (91). As highlighted by Kathlyn J. Peck, reducing anxiety and agitation enhances the ability to focus and encode new information (47). Thus, MT serves as a powerful tool in supporting episodic memory, fostering emotional recall, and alleviating stress, ultimately improving memory outcomes for individuals with AD.

As noted previously, emotions play a crucial role in the encoding and retrieval of memories, making emotional engagement through music particularly beneficial for

AD patients. Self-selected music, where patients choose music that resonates with them, can deepen emotional reflection and introspection (92). This process may trigger memories linked to the emotions evoked by the music, leading to enhanced memory recall (93). Self-selected music has been linked to an increase in the use of emotional language during recall, highlighting its potential to support memory retrieval in AD patients. This underscores the effectiveness of MT in facilitating cognitive functions through emotional engagement (39).

Neuroscience researcher Jörn-Henrik Jacobsen utilized PET to investigate the degree to which music-listening areas are affected by AD pathology, such as amyloid build-up and glucose metabolism, and found that music-listening areas showed less pathology (36). This suggests that areas responsible for music processing may be more resilient to the degenerative effects of AD. Jacobsen's research supports two possible explanations for this observed resilience. First, it is possible that listening to music actively engages these relatively preserved brain areas, which could help maintain their function and possibly slow cognitive decline. Alternatively, these resilient music-processing areas might be used as a shortcut to stimulate other cognitive functions. Engaging these areas could therefore help compensate for degeneration in other regions.

In addition, Arroyo-Aniló examined the effect of familiar music on self-consciousness in AD patients. In this study, participants were grouped to listen to music that is familiar or unfamiliar, which refers to music that is not specifically tailored to the individual's preference. Results showed significant cognitive decline only from the non-familiar music listening group (88). This finding suggests that familiar music personalized to an individual's preference may have a stabilizing or beneficial effect on cognitive function in people with mild to moderate AD.

In addition to the mainstream works of research by Jacobsen and Arroyo-Aniló, many different methods of utilizing preferred music to explore its benefits on episodic memory retrieval exist. For example, functional MRI data shows that the precuneus regions within the default mode network (DMN) were most connected when listening to preferred music regardless of the type of music or the presence or absence of lyrics. In AD, dysfunction in the precuneus can lead to cognitive issues like memory problems or lack of awareness (94). Also, the DMN is known to support functional brain states, such as the reprocessing of memories and introspection (95). Preferred music allows for a deeper, emotion-based connection, enabling individuals to form more personal associations with the music. This emotional connection facilitates the retrieval of memories, particularly those tied to significant life experiences. By engaging the DMN, which is involved in reflective thinking and memory retrieval, personalized MT can enhance an individual's sense of self (96). It offers a powerful way to reconnect with personal memories, fostering a stronger identity and improving quality of life. This connection can also enhance relationships with family members and the broader world, as it allows individuals to access memories and emotions that are deeply meaningful to them (97).

CONCLUSION

This review has highlighted the growing body of evidence supporting the positive effects of MT interventions for individuals with AD. However, there is still limited research on the specific brain changes these interventions induce. Most studies focus on standardized behavioral assessments, such as the Mini-Mental State Exam (MMSE) and Cognitive Abilities Screening Instrument (CASI), while neuroscience research examines brain activity at various scales (94). Also, the use of gamma-frequency stimulation in clinical settings in order to further assess the relationship between MT and AD pathology is limited by its perceived unpleasantness. For instance, some patients may find the auditory stimuli associated with gamma-frequency stimulation uncomfortable, as the high-frequency sounds can feel irritating. The combination of this stimulation with music could complicate the therapeutic process, as the music might clash with the frequencies used for stimulation, creating a less enjoyable experience overall (85).

Methods of MT provide an affordable, non-invasive alternative to traditional AD treatments, potentially improving the quality of life for patients and reducing isolation (98). They also offer a flexible solution for dementia care, which can reduce healthcare costs. By promoting emotional and social engagement, MT may also help enhance interpersonal connections in patients with AD (98). Moreover, music is a highly accessible tool that allows for easy customization to individual preferences, which enhances patient engagement (99). Music can be delivered through various formats such as recordings and live performances, making it suitable for diverse settings. While the accessibility of music is important, further research is needed to increase flexibility in its use in AD treatment, unlocking its full potential to improve patient outcomes (100). This exploration could pave the way for innovative therapeutic strategies that effectively utilize the transformative power of music.

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