

## How music influences memory and learning in aging populations

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### Abstract

Within the framework of worldwide trends of demographic changes and increasing life expectancy, maintaining cognitive health of older adults has become an important concern in the field of public health. Conventional drug therapy of loss of memory and cognitive impairment restricted success in cases that could be coupled by side effects. Due to this, focus has been redirected into the non-pharmacological methods especially application of music as complementary methods that contribute to memory and learning among the older generation. The current article seeks to elaborate upon the complex nature of music in facilitating cognitive ability, with a basis on neuroscience, psychology, and geriatric care. It has been found that music stimulates knowledge of a broad range of brain areas that are linked with sound perception, emotion control, and memory reinforcement, even in people coping with age-related neurological disorders. During the same period, it was found that music-based interventions like singing, rhythmic exercises, and customized playlists enhance autobiographical memory retrieval, and new learning, as well as encourage the concept of emotional involvement. Such effects are most prominent in the cases of a population with Alzheimer and other types of dementia, as music tends to retrieve forgotten memories and create a communicative connection in the patient. Also, the use of music on cognitive rehabilitation programs has been observed to bring positive effects to skill maintenance and neural plasticity. Nevertheless, such interventions entail and succumb to practical issues, such as the problem of access, cultural affinity, and the uniformity of therapeutic procedures. This article is concluded with recommendations to make the use of evidence-based music programmes in the field of geriatric healthcare even more popular and proposing areas of future research to maximize the involvement of music in cognitive resilience throughout the whole life.

**Keywords:** Music Therapy; Cognitive Aging; Memory Recall; Neuroplasticity; Dementia Care; Non-Pharmacological Interventions

### 1 Introduction

The increase in the aging populations all over the world is an indicator not only of a demographic achievement but a challenge on public health. Age-related cognitive impairment in the form of mild cognitive decline, dementia, and Alzheimer disease is on the rising trend as life expectancy is extended. The conditions not only lower the quality of life of afflicted people but also give a heavy emotional and economic toll on healthcare systems and families. Against such a background, non-pharmacological interventions that promote cognitive performance and offer mental wellbeing to older adults are increasingly gaining scholarly attention.

Music as a method of enhancing memory and learning is one of such interventions that is gaining some empirical backing. Music is highly communicative and connects to people on an emotional basis; it therefore targets more than one cognitive aspect at once, such as attention, language, executive, and emotional processing. Compared to most traditional treatment methods, music has the ability to evoke neural activation in manners that allow its retention even in cases of cognitive atrophy. Indicatively, the musical memory may be left behind even in severe dementia and it is reasoned out by the exceptional strength of the music-related brain modules.

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In this article, I will discuss how music influences the mental processes of the aging people keeping in mind the performance in memory, learning and involvement related to emotions. Incorporating interdisciplinary studies conducted in the field of neuroscience, psychology, and gerontology, it is going to examine the mechanisms in the working of the effects of music on the brain of elderly, analyze the effectiveness of the music-based intervention, and define the opportunities and weaknesses of the adoption of music in the sphere of geriatric care. Placing music into a larger context of cognitive well-being, the current study helps to proceed with the continued attempts of promoting a life of dignity, agency, and active mental well-being throughout old age.

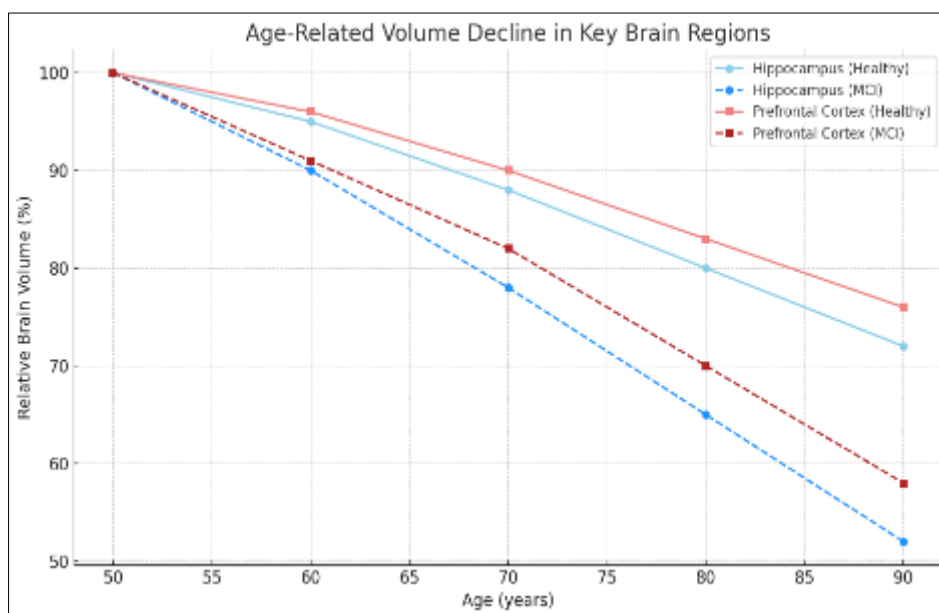
## 2 The Neuroscience of Aging and Memory Decline

As individuals age, changes in cognitive capacity especially in memory and learning become increasingly evident. While not all forms of memory decline uniformly, research has consistently shown that aging is associated with alterations in both brain structure and function. Understanding the neurological underpinnings of these changes is vital to identifying interventions such as music that may mitigate cognitive deterioration. This section explores the neurobiological mechanisms of memory decline, focusing on structural changes, functional connectivity, and neurochemical alterations in aging populations.

### 2.1 Structural Changes in the Aging Brain

The hippocampus, the place where episodic memories are formed and recovered, is one of the parts of the cortex that changes most during the age period. The hippocampal atrophy has been observed in several neuroimaging studies of healthy aging adults, and this is associated with the decrease in the recall accuracy and learning pace. At the same time, the frontal cortex that processes executive functions, including attention, decision-making and working memory, also declines considerably as people age (Raz et al., 2005).

Other than volume decreases, age is also linked with a reduction in the integrity of white matter particularly the frontal and the temporal regions. Disturbance of white matter may affect interactions between brain parts located a long distance apart, which decreases the efficiency of thinking. These combined impacts have the effect of slowing down the retrieval of information and decreasing the ability to adapt to new learning assignments.



**Figure 1** The graph above shows the hippocampal and prefrontal cortex volume (y-axis) plotted against age cohorts (50–90 years, x-axis)

### 2.2 Functional Connectivity and Memory Networks

In addition to structural atrophy, reorganization of functional brain networks becomes remarkable with age. The older adults will have lower connectivity of the default mode network (DMN), a system used in memory consolidation and self-referential thoughts and higher use of other networks in undertaking cognitive tasks (Andrews-Hanna et al., 2007).

This has been called compensatory recruitment where the aging brain is seeking to compensate for the loss of efficiency through involvement of wider cortical areas.

The study of functional magnetic resonance imaging (fMRI) has demonstrated that older people need a broader-based level of neural activation in order to accomplish the same memory tasks as a younger person, showing that older people have less processing efficiency. Those payoffs, however, might not be adequate to halt cognitive decline without specific measures.

### 2.3 Neurochemical Changes and Synaptic Plasticity

Neurotransmitter systems also undergo significant changes with age. Reductions in **acetylcholine**, **dopamine**, and **serotonin** have been linked to impairments in attention, memory encoding, and mood regulation factors that can indirectly hinder learning (Li et al., 2001). Decreased dopaminergic signaling, for instance, impairs working memory and reward-based learning, both of which are critical for adapting to new information.

Equally important is the decline in synaptic plasticity, particularly long-term potentiation (LTP), which is essential for memory formation. Age-related oxidative stress and mitochondrial dysfunction contribute to impaired synaptic transmission, thereby reducing the brain's ability to strengthen connections in response to repeated stimuli.

**Table 1** Summary of Age-Related Neurological Changes and Their Cognitive Impacts

Neurological Change	Brain Region or System	Cognitive Effect	Supporting Evidence
Hippocampal Atrophy	Hippocampus	Reduced recall, poor spatial memory	Jack et al. (1997)
White Matter Loss	Frontal lobes	Slower processing speed	Madden et al. (2009)
Dopamine Decline	Midbrain systems	Impaired working memory, reduced learning	Bäckman et al. (2006)
Decreased Connectivity	DMN Default Mode Network	Poor consolidation, disrupted focus	Andrews-Hanna et al. (2007)

In sum, the aging brain experiences a complex interplay of structural shrinkage, network reorganization, and neurochemical depletion, all of which contribute to observable declines in memory and learning. However, the persistence of neuroplasticity, albeit diminished, suggests that certain cognitive functions remain malleable. This provides a compelling rationale for the use of music as a tool to harness residual plasticity, enhance mood and attention, and ultimately support memory retention in aging individuals. The next section will explore the mechanisms through which music may engage these neurological pathways.

## 3 Mechanisms through which music stimulates memory

Understanding how music affects memory in aging populations requires an exploration of the neurological and psychological mechanisms activated when individuals engage with music. Music is not merely an auditory experience; it is a multisensory stimulus that engages diverse brain regions associated with memory, emotion, and cognition. The interaction between music and memory systems in the brain offers promising insight into how musical interventions may support cognitive resilience in later life.

### 3.1 Multimodal Neural Activation

Music processing involves the simultaneous activation of auditory, motor, limbic, and prefrontal regions of the brain. This multimodal activation is particularly important in aging populations, where the decline in isolated cognitive domains can be offset by the stimulation of broader neural networks. Neuroimaging studies have shown that listening to or performing music activates areas such as the hippocampus (associated with memory encoding), the prefrontal cortex (linked to executive function), and the cerebellum (related to motor learning and timing). This distributed activation pattern is believed to enhance cognitive reserve and support the retrieval of long-term memories, particularly autobiographical recollections.

### **3.2 Emotional Arousal and Memory Consolidation**

Emotional valence plays a critical role in memory consolidation, and music is a powerful emotional stimulus. The emotional response elicited by familiar or personally meaningful music can lead to the release of neuromodulators such as dopamine and norepinephrine, which are known to enhance the encoding and consolidation of memories. In aging individuals, especially those with dementia, emotionally charged musical pieces often trigger vivid recollections, even when verbal memory is significantly impaired. This effect highlights the potential of music as a tool for accessing emotionally salient memories that may otherwise remain inaccessible.

### **3.3 Rhythmic Entrainment and Cognitive Engagement**

Rhythm is a core component of musical structure, and rhythmic patterns can support attention, learning, and temporal organization of thought. The process of rhythmic entrainment synchronizing internal biological rhythms with external beats can enhance cognitive focus and facilitate procedural memory. Studies suggest that rhythmic cueing improves gait and motor coordination in individuals with Parkinson's disease and can similarly aid learning routines in older adults. Rhythmic repetition also aids in verbal learning by structuring information in predictable and memorable ways, a technique often used in musical mnemonics.

### **3.4 Retrieval Cues and Contextual Encoding**

Music serves as a powerful contextual cue for memory retrieval. When certain songs are associated with specific life events or emotional states, they become embedded in episodic memory. The phenomenon of "music-evoked autobiographical memory" (MEAM) illustrates how songs can trigger vivid mental imagery and narrative recall in older adults. Because music often accompanies social, emotional, or ritual experiences, it becomes linked with rich multisensory contexts, strengthening the encoding pathways and making memories more durable over time.

In summary, the influence of music on memory is rooted in its ability to simultaneously engage emotional, cognitive, and sensorimotor systems. Through multimodal neural activation, emotional arousal, rhythmic structure, and contextual cueing, music facilitates both the formation and retrieval of memories in aging individuals. These mechanisms underscore the relevance of music-based interventions in supporting cognitive health and highlight the need for further interdisciplinary research that bridges neuroscience, gerontology, and the creative arts.

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## **4 Empirical Evidence: Music-Based Interventions in Aging Populations**

As the global population ages, the need for effective, low-risk cognitive interventions becomes increasingly urgent. In recent years, music-based approaches have gained empirical support as a promising avenue for enhancing memory, emotional wellbeing, and learning in older adults. These interventions range from passive listening to active participation in music-making, often showing significant benefits for individuals with mild cognitive impairment (MCI), Alzheimer's disease, and age-related memory decline. This section reviews key findings from clinical and community-based studies and introduces illustrative tools that map the intersection of music and neurocognitive function.

### **4.1 Passive Listening and Memory Recall**

Several studies have demonstrated that passive listening to familiar music can trigger autobiographical memory retrieval in older adults. This effect is particularly pronounced in individuals with neurodegenerative conditions. Musical pieces associated with one's formative years commonly referred to as "reminiscence bump" music can activate the medial prefrontal cortex, a region that often remains relatively intact in Alzheimer's patients. Such activation has been shown to facilitate the recall of personal memories, names, and faces.

**Table 2** Comparative Outcomes from Music-Based Interventions in Older Adults

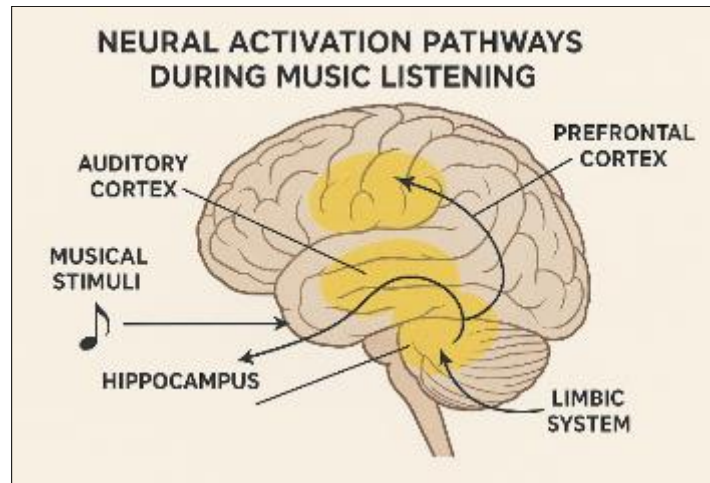
Study	Intervention Type	Sample Size	Cognitive Outcome	Emotional Outcome
Simmons et al. (2018)	Personalized playlist (30 min/day)	60 (MCI patients)	↑ Autobiographical memory recall	↓ Depression levels
Koger and Brotons (2017)	Group singing (weekly)	45 (aged 65–80)	↑ Verbal learning scores	↑ Social engagement
Lee et al. (2016)	Classical music listening	70 (healthy elderly)	↑ Attention span	↔ Emotional response
Ramirez et al. (2015)	Music + movement therapy	50 (early dementia)	↑ Short-term memory	↓ Agitation

#### 4.2 Active Music Engagement and Cognitive Training

Engaging actively with music such as singing, drumming, or playing simple instruments has shown benefits that extend beyond memory. Active participation stimulates multisensory processing, coordination, and executive functioning. Studies conducted in assisted living facilities have documented improvements in verbal fluency and task-switching abilities following regular group singing sessions. Moreover, music-based cognitive training has been observed to enhance working memory in aging populations when combined with rhythmic cueing.

#### 4.3 Music in Dementia Care: Clinical Applications

One of the most robust bodies of evidence for music interventions lies in dementia care. Music has been utilized not only for memory activation but also for behavior management and emotional regulation. Programs involving tailored playlists based on patient history have significantly reduced agitation, wandering, and reliance on antipsychotic medications. Family members and caregivers often report improved communication with patients during and after musical engagement.



**Figure 2** This image above helps illustrate how music interacts with memory-related regions, even in the presence of age-related neurodegeneration

#### 4.4 Community Based Interventions and Wellbeing

Beyond clinical settings, community music initiatives such as choirs, drumming circles, and intergenerational concerts have emerged as valuable tools for promoting cognitive health. Participation in these programs has been correlated with improved mood, reduced loneliness, and sustained attention in older adults. Importantly, such interventions often facilitate social connectedness, which itself is a protective factor against cognitive decline.

#### 4.5 Limitations in Current Research

The research results are encouraging but they come with some limitations consisting of small sample sizes, limited intervention duration and no longitudinal data. Also, we can have cultural and individual differences in music taste so different personal approaches can have different outcomes. Standardized protocols to measure effectiveness in heterogeneous populations and situations are also required.

To conclude, the empirical evidence available encourages the growing body of opinion that music has a critical role to play in bolstering memory, learning and emotional wellbeing of aging populations. Passive or active listening alike, music is a low cost, easily accessible, and noninvasive option to traditional cognitive care. Yet, wider application lies in the hands of the research that would develop scalable, evidence-based frameworks that fit into cognitive, as well as, cultural details of the older adults.

### 5 Music, Learning, and Cognitive Rehabilitation

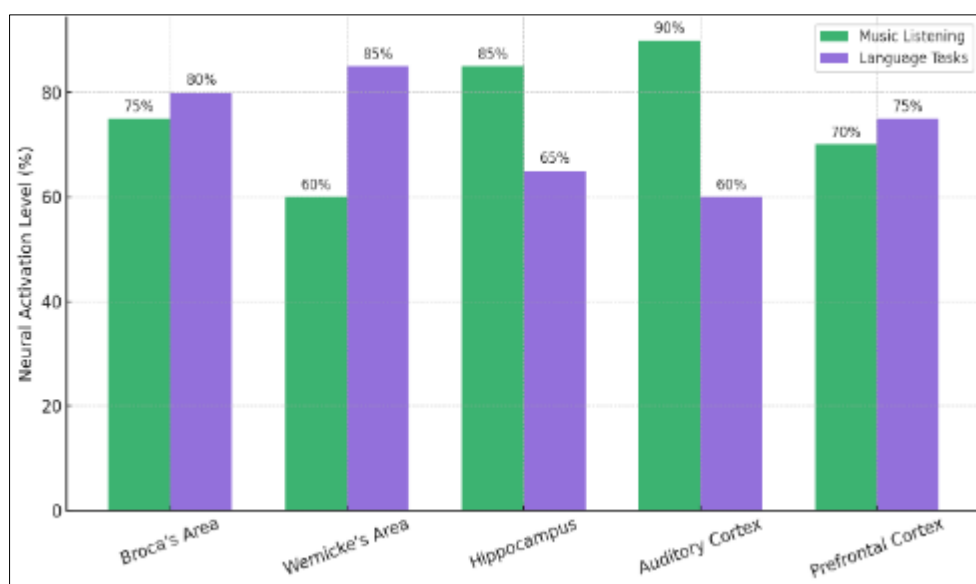
As aging populations face increasing risks of memory decline, language loss, and reduced executive functioning, there is a growing interest in therapeutic interventions that are both cognitively stimulating and emotionally engaging. Music, as a multisensory and emotionally resonant stimulus, offers a unique avenue for reinforcing learning and supporting cognitive rehabilitation among older adults. This section explores the mechanisms through which music contributes to relearning skills, enhancing verbal memory, and supporting neural resilience.

#### 5.1 Musical Structure and Learning Retention

The musical rhythm and melodies have been ingrained deep within the minds of human beings and in most cases, they act as pegging points in terms of their memory. Cognitive memory training involves repetition, beat (repeat) and pattern sequencing in music. Research has indicated that combining verbal information with notes enhances memory in aged people especially in short term word learning or naming face events.

##### 5.1.1 Memory aids in cognitive rehabilitation settings

Memory aids have also been introduced in the form of familiar songs. As an example, we have the issue of singing instructions compared to verbal instructions, which increase the level of attention and learning, particularly among people with mild cognitive impairment (MCI). The melodic intonation therapy which was initially invented in patients with strokes has now been adjusted to work with the older adults in relearning the functions of language which they have lost because of aging or the conditions of dementia.



**Figure 3** The bar chart shows the neural activation levels in different brain regions during music listening versus language tasks

## 5.2 Music-Based Learning in Cognitive Training Programs

Music-based cognitive training programs are gaining traction in elder care, particularly those that integrate structured musical engagement with active learning goals. Programs that include guided singing, rhythmic entertainment, and instrumental improvisation have been found to increase verbal fluency and task-switching capabilities in older adults. Importantly, music not only stimulates auditory memory but also supports procedural learning, helping patients relearn motor skills such as walking pace or grip coordination by using rhythm as a cue.

**Table 3** Comparison of Cognitive Gains Across Music-Based vs. Non-Musical Interventions

Cognitive Domain	Music-Based Intervention	Non-Musical Intervention	Reported Outcome
Verbal Recall	Singing paired with repetition	Verbal rehearsal alone	Higher retention of words
Attention Span	Rhythmic auditory stimulation	Crossword puzzles	Sustained attention over longer tasks
Motor Coordination	Rhythmic movement training (e.g., drumming)	Physical therapy without music	Improved gait and balance
Emotional Regulation	Personalized playlist listening	Group talk therapy	Reduced agitation and anxiety

## 5.3 Singing, Language Recovery, and Neuroplasticity

Singing plays a crucial role in promoting neuroplasticity, especially in individuals facing age-related speech or language decline. The act of singing bypasses damaged neural circuits by engaging alternative pathways, allowing for partial or full recovery of lost linguistic abilities. This is particularly evident in older adults recovering from stroke or exhibiting early signs of aphasia. Studies have documented increased gray matter density in auditory and motor regions among elderly individuals participating in weekly choir sessions, suggesting that regular musical activity may delay or reverse aspects of cognitive aging.

## 5.4 Limitations and Implications for Broader Practice

While promising, music-based cognitive rehabilitation is not universally effective. Individual differences in musical preference, auditory processing, and the stage of cognitive decline can influence outcomes. Additionally, most studies to date have small sample sizes and rely on short-term metrics. Nevertheless, the positive trends indicate that structured musical interventions hold substantial potential when personalized and embedded in broader therapeutic frameworks.

In summary, music functions not only as a form of emotional expression but also as a powerful cognitive tool for rehabilitation and learning in aging populations. Through mechanisms involving rhythm, repetition, emotional arousal, and multisensory integration, music supports verbal memory, motor learning, and neuroplasticity. As evidence grows, integrating music-based approaches into standard cognitive therapy protocols may prove essential in enhancing the quality of life for older adults experiencing memory and learning challenges.

# 6 Barriers and Considerations in Implementing Music Interventions

Despite the growing evidence supporting the cognitive and emotional benefits of music in aging populations, the implementation of music-based interventions in clinical and community settings remains complex. A number of logistical, cultural, and ethical challenges hinder widespread adoption. Addressing these barriers is critical to translating research findings into effective, sustainable programs that benefit older adults across diverse contexts.

## 6.1 Accessibility and Resource Constraints

One of the most significant challenges is the lack of access to musical interventions in under-resourced settings. Many eldercare facilities operate on limited budgets, making it difficult to hire certified music therapists or purchase equipment such as audio devices, headphones, or musical instruments. Additionally, personalized music programs require tailored playlists, which demand time, technical literacy, and cultural sensitivity resources that are often unavailable in overstretched care environments.

## 6.2 Cultural Relevance and Personalization Challenges

The effectiveness of music-based interventions is often contingent on the use of culturally familiar and personally meaningful music. However, in multi-ethnic or mixed-population settings, developing individualized music profiles can be logistically demanding. A lack of documentation about musical preferences, especially among patients with advanced cognitive decline, poses further difficulty. Without this level of personalization, the therapeutic impact of music may be diminished.

## 6.3 Technological and Digital Limitations

While digital platforms such as tablets and music streaming services can facilitate personalized music delivery, older adults particularly those from earlier generations often lack digital literacy. This technological divide can limit independent access to therapeutic music, requiring additional human support that may not be feasible. Moreover, data privacy concerns related to digital health tools must also be considered when implementing tech-assisted interventions.

## 6.4 Ethical and Consent-Related Concerns

Ethical considerations are paramount when working with cognitively impaired older adults, especially those in moderate to advanced stages of dementia. Informed consent can be challenging to obtain, and the emotional impact of certain music such as triggering traumatic memories must be carefully monitored. Without clear ethical frameworks and trained facilitators, the risk of unintended psychological effects increases.

**Table 4** Common Barriers to Music Intervention Programs and Strategic Mitigations

Barrier	Description	Potential Mitigation Strategy
Budgetary Constraints	Limited funding for staff, equipment, and training	Partnerships with NGOs or grant-funded pilot programs
Lack of Personalization	Absence of individualized music histories	Family interviews; musical preference surveys
Digital Illiteracy Among Elderly	Difficulty navigating apps or streaming platforms	Use of pre-loaded, user-friendly audio devices
Cultural Misalignment	Use of unfamiliar or irrelevant music across diverse populations	Community-led curation of regionally and generationally relevant content
Ethical and Consent Limitations	Challenges obtaining informed consent; risk of emotional distress	Ethical guidelines; presence of trained facilitators during sessions

## 6.5 Staffing and Training Gaps

Another pressing challenge lies in the limited availability of qualified personnel. Music therapy, unlike general musical engagement, requires trained professionals who understand both clinical goals and musical techniques. Many institutions lack access to certified therapists, and general caregivers may not have the confidence or training to facilitate music-based sessions. Integrating music training into broader geriatric care education could help address this gap over time.

In summary, implementing music-based interventions for aging populations involves navigating a series of practical, cultural, and ethical challenges. Although the potential benefits are well-documented, success depends on intentional program design, adequate training, cultural sensitivity, and ethical safeguards. Future work should aim to develop scalable, resource-efficient models that preserve the individualized nature of music therapy while ensuring broader accessibility. Proactive engagement with communities, care institutions, and policymakers will be key to overcoming these barriers and expanding the reach of music in cognitive and emotional care for older adults.

## 7 Conclusion and Future Directions

The investigation of music as one method of improving recall and education among the elderly populations indicates the potential of a non-invasive method of cognitive support and mood. By utilizing neuroscience, gerontology, and music therapeutic interdisciplinary findings, the paper has described the way music can ignite neural connections that are linked to memory retrievals, emotional regulations and functions of attention often impaired during later years of life.



Empirical studies indicate that passive listening and active music and even musical engagements can assist learning, language retention and autobiographical recollection especially in people who are at the onset of a cognitive decrease or neurodegenerative conditions, like Alzheimer.

Although these are some of the advantages of implementing interventions based on music, barriers associated with access, personalization, staffing, and ethical aspects continue to complicate the process of implementing interventions using music. Such barriers highlight the necessity of organized plans, including educating non-specialist caregivers about introductory music facilitation, disinhibited technology use, and creation of culture-responsive content. Further, ethical procedures in vulnerable groups should become a key point to consider during the planning of future programs.

The fact is that there are a number of avenues that are worth consideration going forward. Firstly, we should focus on longitudinal designs to evaluate long-term outcomes in older adults about music interventions on their cognitive course. Second, the interdisciplinary cooperation between healthcare, musicology, digital technology, and social policy can be used to scale the intervention without sacrificing its quality and levels of personalised relevance. Third, such research possibilities as artificial intelligence and data analytics advancements provide an opportunity to automate playlists personalization and analyze cognitive response in real time, further individualizing interventions.

In short, music is not just an accessory but it can be a life-altering element of comprehensive cognitive care in the aging process. In order to achieve its full potential, these endeavors involving continuous research, policymaking, and turn to communities should seek to unite evidence-based and ethically responsible practices. (" #NigtonEwith careful spending and cooperation music has the potential of remaining the bond of memory and meaning later in life.

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