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Cognitive, emotional, and neural benefits of musical leisure activities in aging and neurological rehabilitation: a critical review

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Abstract

Music has the capacity to engage auditory, cognitive, motor, and emotional functions across cortical and subcortical brain regions and is relatively preserved in aging and dementia. Thus, music is a promising tool in the rehabilitation of aging-related neurological illnesses, such as stroke and Alzheimer disease. As the population ages and the incidence and prevalence of these illnesses rapidly increases, music-based interventions that are enjoyable and effective in the everyday care of the patients are needed. In addition to formal music therapy, musical leisure activities, such as music listening and singing, which patients can do on their own or with a caregiver, are a promising way to support psychological well-being during aging and in neurological rehabilitation. This review article provides an overview of current evidence on the cognitive, emotional, and neural effects of musical leisure activities both during normal aging and in the rehabilitation and care of stroke patients and people with dementia.

Keywords: music; intervention; cognition; emotion; aging; rehabilitation; stroke; dementia

Introduction

Our ability to perceive, produce, and enjoy music is considered a universal trait present in all cultures across history and with us throughout life, from early childhood to old age. For the human brain, music arguably ranks among the most powerful and diverse sensory, motor, cognitive, and emotional experiences. Today, musical leisure activities are highly widespread: most people engage with music daily, by listening, singing, dancing, or playing. A feature common to all these activities — and possibly the key reason why we are drawn to music — is the capacity of music to evoke and regulate emotions, provide enjoyment and comfort, and relieve stress [1]. Depending on our current psychological state and needs, music can serve different functions: it can energize or relax us, focus or distract us, help us remember or forget, isolate us from the environment or unite us with others. During the past years, these subjective experiences of the emotional and cognitive impact of music have received increasing experimental and scientific support that music evokes strong emotions [2], influencing our autonomic nervous system and neuroendocrine systems [3]; enhances cognitive functioning [4]; and activates the brain extensively, engaging multiple temporal, frontal, parietal, cerebellar, and limbic regions [5].

Given the rapid aging of the world's population and the increasing societal burden brought about by aging-related sensory, cognitive, and motor decline, interest has focused on the potential of music-based interventions to promote brain and cognitive reserve and emotional well-being during normal aging. Similarly, in response to the growing prevalence of many aging-related severe neurological illnesses, such as stroke and Alzheimer's disease (AD), many music-based rehabilitation methods have been developed to enhance recovery or sustain functioning in the cognitive, motor, language, emotional, or social domain. Broadly speaking, these music interventions can be classified as music therapy, implemented by a trained music therapist and following an established music therapy protocol, or other music-based interventions, comprising musical activities implemented by other professionals (e.g., nursing staff), the patients themselves, or family caregivers. Both formal music therapy and other music-based interventions can involve active/expressive (music playing, singing, dancing) and receptive (music listening) musical components. However, the key difference is that in music therapy, the components are performed within a therapeutic relationship, which typically evolves during the intervention and utilizes musical dialogue and interaction between the therapist and client, to accomplish individualized goals [6].

Recent reviews have examined the effects of formal music therapy in stroke [7] and dementia [8]. This article focuses on other music-based interventions and provides an overview of current research on the effects of musical leisure activities, such as music listening, singing, instrument playing, and dancing, on cognitive, emotional, and neural functioning during normal (healthy) aging

and in the care and rehabilitation of people with aging-related neurological diseases, particularly stroke and dementia.

Musical activities during healthy aging

Emotional and social impact of musical activities

Although the emotional and social impact of music in adolescence as a means for constructing the self-identity, forming interpersonal relationships, and dealing with stress and negative emotions is often emphasized, music continues to play an important role also in adulthood and old age as a way for regulating mood; evoking memories; maintaining self-esteem, competence, and independence; and reducing feelings of loneliness and isolation [1,9]. This latter function is of paramount importance given that loneliness and low social participation are known to be associated with incident dementia [10]. Music listening is a common, everyday leisure activity for older adults that is linked to positive emotions and contributes to psychological well-being [11]. Recently, participatory group musical activities, especially community or choir singing, have received increasing interest as potential ways to maintain health and psychological well-being during aging [12-15].

Questionnaire and interview studies of healthy older adults participating in community choirs have reported the self-perceived benefits of choir singing linked to better quality of life (QoL), less depression, and satisfaction with health [12], bringing about enjoyment, cognitive stimulation, better physical and mental health, and increased social interaction. Similarly, in a non-randomized longitudinal study, Cohen et al. [13] compared 90 older adults participating in a 30-week choir program with 76 control older adults over a 12-month period and found choir singing associated with better self-rating of health and morale, less loneliness, and improved level of activity. Recently, the long-term efficacy of community singing was evaluated in a randomized controlled trial (RCT) in the United Kingdom. In this pioneering RCT, Coulton et al. [14] followed a large group (n = 258) of healthy older adults, half of whom participated in 3-month community singing intervention for 6 months, by using measures of QoL, mood, and health utility. The singing intervention had a long-term positive effect on health-related QoL and a short-term positive effect on mental health-related QoL, anxiety, and depression [14]. Overall, singing was reported to be more cost-effective than usual activities [14]. Also, qualitative analysis of the subjective experiences of the participants provided converging results that the singing groups led to better physical, psychological, social, and community well-being [15].

Cognitive and motor impact of musical activities

By inducing positive affect and heightened arousal, exposure to music (often with fast tempo and in major mode) can temporarily enhance cognitive performance, also in older people. Studies comparing the short-term effects of background music versus no music in older adults have reported enhanced performance in tasks of psychomotor speed [16], verbal fluency [17], and episodic memory [16,18] induced by the music. In contrast, one study reported that background music had a distractive effect on cognitive performance in a visual associative memory task in older adults [19]. Also, the cognitive effects of regular musical activities have recently been the focus of active study. Older people who had long-term musical training earlier in life have been found to have faster performance and neural timing in language tasks [20] as well as enhanced auditory attention [21] and executive function, including working memory and cognitive control [22].

Similarly, instrumental musical training, such as learning to play a piano, or music-based cognitive training in old age has been found to improve performance on attention and executive tasks [23,24] as well as enhance mood and QoL [21]. Recently, a 6-month weekly dance intervention was found to improve posture, motor and tactile performance, cognitive function, and subjective well-being in older people [25]. The association between musical activity and cognitive well-being was also found in large prospective cohort study (n = 469) of people ≥ 75 years [26] that assessed the relationship between different leisure activities and risk of dementia. Risk of dementia was reduced with the leisure activities reading and playing board games as well as playing musical instruments and dancing [26]. Taken together, musical leisure activities seem to be clearly beneficial for seniors and may be an effective means to combat age-related cognitive decline.

Musical activities in aging-related neurological diseases

Musical activities in stroke

Aesthetic and cultural leisure activities, such as listening to music or dancing, are important for stroke survivors, but unfortunately, stroke patients are often not able to participate in these activities because of health issues or inaccessibility of services. Even in rehabilitation centres, stroke patients typically spend 50% to 70% of their daily time not engaged in therapeutic activities or social interaction [27], and many patients consider that their rehabilitation needs are not properly met. During the last 10 years, there has been growing interest in the application of musical activities to support cognitive, motor, and emotional recovery from stroke and enhance brain plasticity during the recovery period.

Among different everyday musical activities, self-implemented music listening is perhaps most easily applicable in the rehabilitation setting. Särkämö et al. [28-31] performed a parallel-group RCT comparing the long-term effects of a 2-month daily music listening intervention to an audio-

book listening intervention and standard care in 60 patients with acute stroke. Both the audio book and music material was self-selected and the listening was self-implemented with portable players, with the help of music therapists, family members, and nursing staff. The music material comprised mostly songs with lyrics that were familiar to and preferred by the patients. The outcome was assessed with neuropsychological tests and mood questionnaires as well as auditory magnetoencephalography (MEG) measurements and structural MRI (sMRI) performed at acute, 3-month, and 6-month post-stroke stages. In a 6-month follow-up, music listening was superior to audio-book listening and standard care in improving the recovery of verbal memory and focused attention and reducing depression and confusion [28] and in increasing positive mood, relaxation, and motor activity [29]. Using MEG and voxel-based morphometry analyses of sMRI data, these behavioural gains with music listening were also linked functionally to enhanced neural efficiency of auditory encoding, as indicated by stronger mismatch negativity (MMN) responses [30], and structurally to increased grey matter volume in spared prefrontal (superior frontal gyrus) and limbic (anterior cingulate, ventral striatum) regions [31].

In addition to the generic effects of daily music listening, recent studies explored the use of music-based interventions specifically targeted to the rehabilitation of different cognitive, language, and motor deficits caused by stroke. In 2 small within-subject studies, listening to pleasant music was reported to temporarily alleviate the leftward attentional bias associated with spatial neglect syndrome compared with listening to unpleasant music and no music [32,33], most likely owing to the mood- and arousal-enhancing effect of enjoyable music. Playing musical scales with a keyboard from right to left was recently found to improve the exploration of left side of space in neglect patients in a within-subject case–control study [34]. Music-supported training (MST), whereby patients train by playing keyboard and drum pads, could improve fine and gross motor skills and movement parameters of the hemiparetic upper extremity and improve mood in stroke patients in parallel-group RCTs [35-37] and case–control studies [38,39]. In the brain, these effects were coupled with increased motor cortical excitability as measured by transcranial magnetic stimulation [38] and improved connectivity and functioning of motor cortical areas, as evidenced by changes in event-related desynchronization/synchronization on electroencephalography [35] and activity changes in functional MRI (fMRI) motor and music listening tasks [39].

For aphasic stroke patients, melodic intonation therapy (MIT), whereby the patient trains speech production via singing intonation and rhythmic tapping, was found to improve verbal expression (e.g., continuous speech, repetition, and naming) in case reports [40,41] and in one small cross-over RCT [42]. These gains have also been linked to enhanced activation of right-hemisphere frontal speech-motor regions [40] and increased right frontotemporal structural connectivity, as

indicated by changes in the fractional anisotropy of the right arcuate fasciculus [43]. In addition to aphasia, singing-based interventions have been used in dysarthria, a relatively common motor speech disorder after stroke, with 2 small within-subject studies reporting benefits in speech motor coordination (e.g., respiration and articulation) and prosody [44] and in speech intelligibility and naturalness [45].

Group-based music interventions have received much interest; these have the added value of being more widely applicable and involving a social interaction element as compared with individual-based methods. The MST protocol has been found equally effective motorically and emotionally when applied in individual and pair settings [37]. Also, the effects of choir singing have recently been explored in 3 small pilot studies. Stroke and Parkinson disease patients perceived participating in a community choir as qualitatively helpful in the self-management of the social and emotional consequences caused by the illnesses (e.g., social isolation, low mood, and communication deficits) [46]. In a within-subject study [47], 13 aphasic stroke patients reported reduced psychological distress and enhanced confidence, mood, motivation, and communication after weekly participation in a community choir. Recently, in a pilot parallel-group RCT of 23 chronic aphasic patients, Zumbansen et al. [48] compared the effects of weekly choir and drama group interventions to standard care. No significant outcome effects were observed for the interventions, but the level of attendance at the social activities was linked to improved functional communication, and the protocol was found feasible.

Musical activities in dementia

Given the markedly increasing prevalence of AD and other dementia illnesses and the associated growth in individual suffering, caregiver burden, and societal costs, there is a pressing need for effective ways to support the cognitive, emotional, and social functioning in this population, both in people with dementia (PWDs) and their family members and caregivers. Importantly, music-induced emotions and memories are often preserved even in more advanced stages of dementia [49], possibly because of the relative preservation of medial frontal and limbic areas in AD [50], which enables the therapeutic use of music across the dementia spectrum, from mild cognitive impairment to severe dementia.

Regarding the immediate effects of music in PWDs, pleasant and stimulating background music has been found to temporarily reduce anxiety [51] as well as enhance awareness [52] and cognitive performance in tasks of episodic (autobiographical) memory [51,53] and verbal fluency [17]. AD patients have also been shown to better recall verbal material presented in a musical (as song lyrics) versus spoken context [54]. In addition, a number of small-scale intervention studies of

PWDs with moderate-severe dementia residing in a long-term care facility have assessed the emotional and social impact of caregiver-implemented musical leisure activities, primarily using the listening of individualized (preferred) music, over a short time period (days or weeks). These studies and have reported short-term beneficial effects of music on anxiety [55], agitation [56], and positive social behaviors and interaction [57]. Although a few studies have reported no significant benefits of musical activities on neuropsychiatric symptoms as compared with another control intervention [58] or standard care [59] in moderate–severe dementia, overall, the evidence seems to suggest that exposure to music has an immediate positive emotional and cognitive effect and that songs may function as a mnemonic aid in dementia.

In addition to music intervention studies in more advanced dementia, recent interest has focused on the efficacy in earlier stages of dementia. Särkämö et al. [60-62] performed a parallel-group RCT in 89 PWDs with mild-moderate dementia and their caregivers (family members and nurses), comparing the short- and long-term efficacy of two 10-week music interventions that focused on coaching the caregivers of PWDs to use either regular singing or listening of familiar songs with the PWD at home or in a care unit to standard care. The music coaching intervention entailed identifying which songs were emotionally and autobiographically most important to the PWD and instructing the caregivers on how to use music with the PWD in everyday life for different purposes (e.g., relaxation, reminiscence, and vitalization). Also, regular musical "homework" was included to root the activity to the everyday home setting. The outcome was assessed by neuropsychological tests and mood and QoL questionnaires performed at baseline, after the intervention, and 6 months later. Both singing and music listening could help maintain general cognition (Mini-Mental State Examination) and executive function and alleviate depression [60]. However, singing was more effective than music listening or standard care in enhancing working memory and episodic (autobiographical) memory, especially in PWDs with mild dementia, and in reducing the psychological stress and burden experienced by caregivers [60,61]. The positive effects of music on depression were also more prominent in PWDs with mild AD-type dementia [61], and the authors found a partly different pattern of emotional benefits in the 2 music interventions: music listening was more calming and relaxing (reducing agitation), whereas singing was more energizing and refreshing (reducing fatigue) as compared with standard care [62].

Regarding the cognitive effects of singing, converging results have recently been obtained in 2 non-RCT group studies. Maguire et al. [63] reported that 4 months of regular group singing but not music listening improved performance on tests of general cognition and visuospatial processing in PWDs. Similarly, Satoh et al. [64] found that psychomotor speed and mood were improved in PWDs after a 6-month karaoke-based singing training program. These effects were coupled with decreased

parietal activation in an fMRI karaoke task, which suggests improved neural efficiency of cognitive processing [64]. Regarding the social perspective singing, a recent qualitative study [65] of 17 PWD–caregiver couples participating in group singing together suggested that PWDs and caregivers may benefit from the singing activity independently (e.g., supporting identity and confidence in PWDs and providing enjoyment and liberation in caregivers) and that the activity also had a positive relational impact for them as a couple (e.g., enhancing togetherness).

Concluding remarks

From the studies reviewed above, there is now emerging evidence that musical leisure activities or music-based interventions performed outside a formal music therapy context can have many potential benefits for cognitive, motor, emotional, and social functioning for both normal aging and for older people with debilitating neurological illnesses, including stroke and dementia.

Music listening has an enhancing effect on mood and arousal, which can temporarily improve cognitive performance in attention or memory tasks in healthy older adults as well as in stroke patients with neglect and in PWDs. Our own RCT studies indicate that when music listening is regular and frequent, it can facilitate cognitive, emotional, and neural recovery after stroke and support cognitive functioning, mood, and QoL in people with mild–moderate dementia. Active musical hobbies, such as playing an instrument, singing or dancing, can enhance executive functions, mood, or QoL in healthy older adults. As such, regular musical activities hold much promise for maintaining better mood and for QoL and offset the gradual cognitive and neural decline associated with normal aging.

Active playing- or singing-based interventions have shown promising effects in stroke rehabilitation for improving upper-extremity motor recovery, speech production, and mood and also have potential applications in the rehabilitation of neglect syndrome. In PWDs, the specific impact of musical activities seems to depend on the severity of dementia symptoms: positive effects on neuropsychiatric symptoms such as agitation and social interaction are seen with more advanced (severe) dementia, whereas the cognitive benefits of music, such as on working memory, are so far limited to singing-based group interventions for people with mild–moderate dementia.

Overall, although positive findings from individual small studies are converging to support the use of music in neurological care and rehabilitation and in supporting neurocognitive aging, the conclusions that can be drawn regarding the clinical efficacy of music-based interventions are still limited because of the variable methodological quality of the published studies, especially in adhering to the Consolidated Standards of Reporting Trials criteria (e.g., randomization, concealment of participant allocation, blinding, reliability and validity of outcome measures, sample size, statistical analyses, sufficient duration of intervention and follow-up). Among the 29 longitudinal music

intervention studies included in the present review, only 12 used a proper RCT design. In future, large and high-quality RCTs are needed to build a more solid clinical evidence base and to establish the use of music more widely in rehabilitation and care units.

There is also a call for clinical music intervention studies combining behavioural outcome measures with neurophysiologic and -endocrinologic markers as well as structural and functional neuroimaging methods that can better elucidate the neural mechanisms underlying the efficacy of music interventions and, eventually, help target the interventions at the individual level for different neurological disorders. With regard to neurocognitive aging, one of the key questions for future research that has not yet been addressed in any large-scale trial with long-term (many years) follow-up is whether the combination of cognitive, motor, and social stimulation provided by active music interventions could have a neuroprotective effect for neurodegenerative diseases and whether it could slow the progression of cognitive symptoms in the early stages of dementia.

Conflicts of Interest The author declares no conflict of Interest.

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