ORIGINAL ARTICLE

INVESTIGATION OF AGE-RELATED CHANGES IN THE MUSICAL PERCEPTUAL SKILLS OF MUSICIAN AND NON-MUSICIAN ADULTS

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Cihan ASLAN[2]
Uğur Embiye ÖZGÜR[3]
Ayşe Sanem ŞAHLI[1]

[1] Hacettepe University, Vocational School of Health Services Hearing and Speech Training Unit, Ankara, Turkey

[2] Nisantasi University, Health Services Vocational School, İstanbul, Turkey

[3] Istanbul Aydin University, Faculty of Health Sciences, İstanbul, Turkey

Correspondence

Ayşe Sanem ŞAHLI
Phone : +905356594775
e-mail : ssahli@hacettepe.edu.tr

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Abstract

Introduction: Our study examined age-related changes in the musical perception skills of musicians and non-musicians.

Materials and Method: This study included two groups. The first group consisted of 40 individuals, including 20 musicians aged 45-64 and 20 musicians aged 65-85. The second group also consisted of 40 individuals, including 20 non-musicians aged 45-64 and 20 non-musicians aged 65-85. Together, both groups comprised 80 adults. Participants' musical perception skills were evaluated using the Musical Perception Test.

Results: The results showed that musicians had higher scores than non-musicians on the Musical Perception Test total score and all music subtests ($p<0.05$). In addition, when age-related changes were examined, musicians between the ages of 45-64 had significantly higher scores than musicians between the ages of 65-85 on multiple instrument recognition, total instrument score, pitch discrimination, total pitch, and total Musical Perception Test scores ($p<0.05$). Similarly, non-musicians aged 45-64 had significantly higher scores than non-musicians aged 65-85 in rhythm recognition, single instrument recognition, total instrument score, musicality, melody recognition, melody recognition in noise, total melody score, and total Musical Perception Test score ($p<0.05$). In the 45-64 age group, there was a significant difference between musicians and non-musicians on all sub-scores except that for rhythm recognition ($p<0.05$). In the 65-85 age group, there was a significant difference between musicians and non-musicians on all scores except pitch recognition, pitch discrimination, and the total pitch score ($p<0.05$).

Conclusion: The results suggest that music education preserves auditory and musical perception skills despite advancing age.

Keywords: Aging; Music; Perception.

INTRODUCTION

Auditory stimuli at various sound levels have features such as rhythm, pitch, melody, and timbre. Musical perception, which varies among individuals, (1) is the process of distinguishing these sound features to identify and make sense of them. Research indicates that music education, in particular, has positive effects on musical perception. Music education improves auditory processing abilities; thus, musicians can better understand speech in noisy environments than non-musicians. Studies have shown that music education leads to greater neuroplasticity in the auditory pathway, which extends from the brainstem to the cortex, and this neuroplasticity improves auditory abilities. (2)

Age-related hearing decline in hearing ability is a ubiquitous part of aging, and it often impacts speech comprehension, especially in noisy environments. While these effects are partly due to changes in the cochlea, they also involve challenges beyond measurable hearing loss. Several studies have observed that central auditory processing skills, as opposed to simple peripheral mechanisms, play a critical role in the management of hearing ability later in life (3).

Recent research has shown that music training in young adults positively alters neural mechanisms and produces long-lasting improvements in auditory abilities and non-auditory tasks involving cognitive control (4). These results suggest that music training can counteract the age-related changes in auditory cognition commonly observed in older adults (5).

Previous studies have shown the positive effects of music training on auditory processing and neuroplasticity. However, the long-term protective role of these effects on age-related changes in musical perception has not been adequately investigated. This study aims to contribute to the literature by objectively evaluating the effect of music education on auditory cognitive changes due to aging with MPT test.

However, with this study examined age-related changes in the musical perception skills of musicians and non-musicians. The participants' performance was measured using the Musical Perception Test (MPT), which we used to determine the level of protection offered by music education in musical perception skills despite advancing age.

MATERIALS AND METHOD

Permission to conduct the study was obtained from the Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee on 08.06.2023 with Decision No: 502. This study was conducted at the Istanbul Aydın University Audiology Laboratory between June and August 2023.

Two groups were included in this study. The first group consists of 40 musicians: 20 between the ages of 45-64 and 20 between the ages of 65-85. The 2nd group included 40 non-musicians, 20 between the ages of 45-64 and 20 between the ages of 65-85. Participants were included in the study by voluntary application method; the selection process was carried out through standard forms in order to minimise self-selection bias. The musicians included in the study had at least one year of professional music education. This training was given by the choir conductor in the form of a structured programme with active participation 2-3 days a week for at least 1 year. All of the musicians are actively performing professionally in the choir. The non-musicians did not play any instruments or receive any music education. Both groups included individuals with at least a high-school education level. Participants in both groups were administered the MOCA test and those with a score of 21 and above were included in the study. For both groups, it was ensured that the participants had a moderate socioeconomic level. Individuals with a history of psychological or neurological disorders and those who could not cooperate in the test were excluded.

Method

Participants who agreed to participate in the study signed an Informed Voluntary Consent Form. Afterward, the researcher verbally asked the questions in the Data Recording Form and filled in the answers. Next, Pure Tone Audiometry evaluations were performed. The Montreal Cognitive Assessment Test (MoCA) was then administered to the participants for cognitive assessment. Participants who scored in the normal range on the MoCA were administered the MPT in a quiet room, using an ASUS-branded computer with the test CD inserted and Supraaural professional headphones with a Sennheiser HD 400 Hi-Fi system.

Data Collection Tools

The Data Recording Form, MoCA test, Pure Tone Audiometry test, and MPT were performed on the participants who voluntarily agreed to participate in the study and met the study criteria.

Data Recording Form

The Data Recording Form, which examined the participants' interests and experiences related to music along with sociodemographic information, was completed before the evaluation. This data form included 25 open- and closed-ended questions. Questions 1-10 asked about age, sex, education, occupation, marital status, socioeconomic status, hearing loss, illness/disability, and medication status, and questions 11-25 collected information about the participants' professional music education, duration and type of music education, playing an instrument, level of interest in music, frequency of listening to music, and their preferred music genre.

Audiological Evaluation

The Pure-Tone Audiometry test was performed with a Maico MA 42 portable audiometer to verify the hearing of the individuals participating in the study. TDH-39 headphones were used to determine the airway thresholds of each ear at octave frequencies of 250-8000 Hz. A Radioear B71 brand vibrator was used to determine bone conduction thresholds of each ear at octave frequencies of 500-4000 Hz. The Pure Sound Average (SSO) was calculated by averaging the thresholds at 500-1000-2000-4000 Hz. Participants with a pure tone average (SSO) of 25 dB or less were considered to have normal hearing thresholds.

Montreal Cognitive Assessment (MoCA)

The MoCA was developed as a rapid screening test for mild cognitive impairment. The test assesses various cognitive functions, including attention and concentration, executive function, memory, language, visual structuring skills, abstract thought, calculation, and orientation. The application of the MoCA required approximately 10 min to complete. The maximum total score obtained on this test was 30. Accordingly, a score of 21 points and above was considered normal. (6)

Musical Perception Test (MPT)

The MAT, originally named the MPT, was developed by Marinda Uys and Catherine van Dijk (7). The necessary permissions were obtained through a protocol between the University of Pretoria and Hacettepe University, and the translation, adaptation, and validity-reliability studies of the test into Turkish were completed by Prof. Dr. A. Sanem Şahlı and Prof. Dr. Erol Belgin in 2016 (8). The adaptation and normalization results of the test were published in 2019 in an international journal using the SCI-expanded index. The MPT is the first and only valid musical perception test in Turkey that can objectively evaluate different music components. The rationale for the selection of the test is its comprehensive subtest structure and the fact that it is supported by previous validity and

reliability studies. To use the test, the researcher must have an MPT Application Certificate. The MPT consists of four domains and 11 subtests on a test CD with 14 audio files, including subtest contents, introductory and closing speeches, Musical Perception Assessment Answer Sheet, and Answer Key. The Answer Key was prepared such that the examiner could evaluate the answer sheet.

Statistical Methods Used in the Data Analysis

Data obtained from both musicians and non-musicians were analyzed using SPSS 25.0. The percentage distributions of both the demographic and music-related characteristics were calculated separately for the two groups. The compatibility of the MPT and MoCA scale scores with a normal distribution was investigated using the Kolmogorov-Smirnov test. The Mann–Whitney U test was used to compare the scores by sex and age groups separately for the musicians and non-musicians. A significance level of α=0.05 was used in all statistical tests. To compare the MPT scores for demographic characteristics, an independent sample t-test was used for independent two-category comparisons, whereas a one-way analysis of variance (ANOVA) was applied for comparisons with three or more categories. In groups where differences were detected, the source of the difference was determined using Bonferroni's multiple comparison test.

RESULTS

The results showed that musicians had higher scores than non-musicians on the total MPT and all music subtests ($p<0.05$) (Table 1).

Table 1: Comparison of the total and subtest scores on the Musical Perception Test (MPT) between musicians and non-musicians

In addition, when age-related changes were examined, musicians between the ages of 45-64 scored significantly higher than musicians between the ages of 65-85 on multiple instrument

Table 1. Comparison of Musical Perception Test (MPT) total score and subtests total scores of musician and non-musician group

Scores	Group	N	$\bar{x}$	SD	z	P[1]
Total Rhythm Score	Musician	40	33.400	3.5717	-5.730	0.000**
	Non-musician	40	26.900	4.3721		
Total Timbre Score	Musician	40	21.420	6.0672	-5.737	0.000**
	Non-musician	40	13.370	3.3713		
Total Pitch Score	Musician	40	14.300	2.71935	-4.262	0.000**
	Non-musician	40	11.800	2.01533		
Total Melody Score	Musician	40	35.970	1.8183	-6.142	0.000**
	Non-musician	40	30.450	4.1931		
Total MPT Score	Musician	40	105.050	11.52244	-6.739	0.000**
	Non-musician	40	82.400	10.53395		

**p<0.05 *p<0.05 1:Mann Whitney U test $\bar{x}$:Mean SD:Standard Deviation

Figure 1. Comparison of Musical Perception Test (MPT) total score and subtests total scores of musician and non-musician group

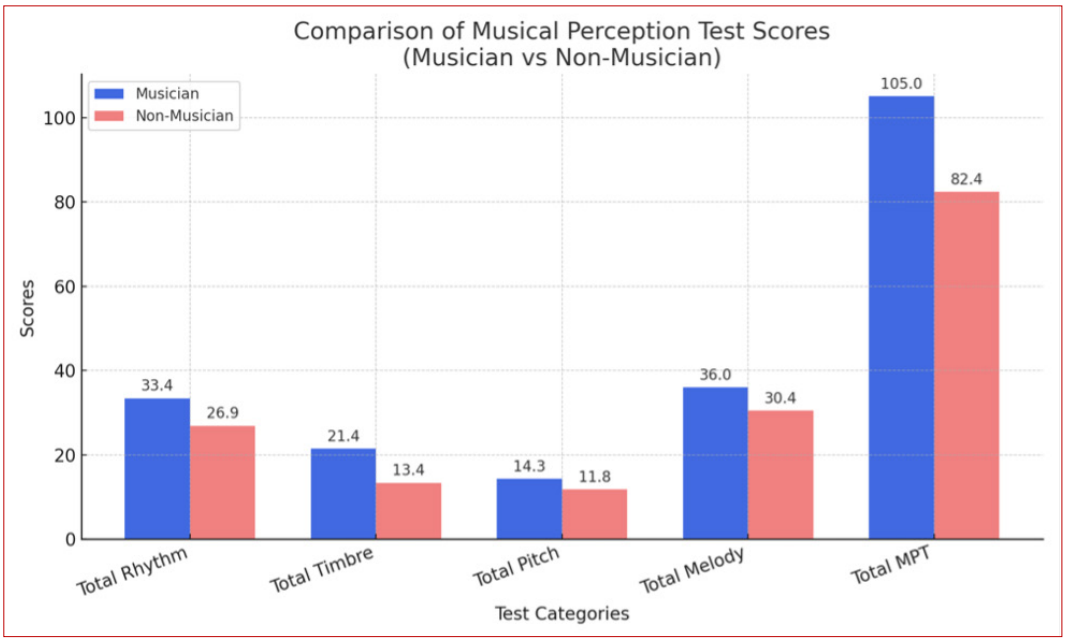


Table 2. Comparison of musical perception total scores according to age group in musician group

Scores	Group	N	$\bar{x}$	SD	z	P[1]
Total Rhythm Score	**45-64**	20	34.35	3.3289	-1.645	0.100
	65-85	20	32.45	3.6342		
Total Timbre Score	**45-64**	20	24.60	5.6138	-3.391	0.001**
	65-85	20	18.25	4.7779		
Total Pitch Score	**45-64**	20	15.50	2.1884	-2.579	0.010**
	65-85	20	13.10	2.7125		
Total Melody Score	**45-64**	20	36.20	1.7947	-0.508	0.611
	65-85	20	35.75	1.8602		
Total MPT Score	**45-64**	20	110.6	11.013	-2.924	0.003**
	65-85	20	99.45	9.2308		

**p<0.05 *p<0.05 1:Mann Whitney U test $\bar{x}$:Mean SD:Standard Deviation

recognition, total instrument, pitch discrimination, total pitch, and total MPT (p<0.05) (Table 2).

Table 2: Comparison of Musical Perception Test (MPT) total scores by age group in musicians

Among non-musicians, individuals aged 45-64 had significantly higher scores than non-musicians aged 65-85 for rhythm recognition, single instrument recognition, total instrument

score, musicality, melody recognition, melody recognition in noise, total melody score, and total MPT ($p<0.05$) (Table 3).

Table 3: Comparison of Musical Perception Test (MPT) total scores by age group in non-musicians

In the 45-64 age group, there was a significant difference between musicians and non-musicians on all scores except for rhythm recognition ($p<0.05$). Similarly, in the 65-85 age group, there was a significant difference between musicians

Figure 2. Comparison of musical perception total scores according to age group in musician group

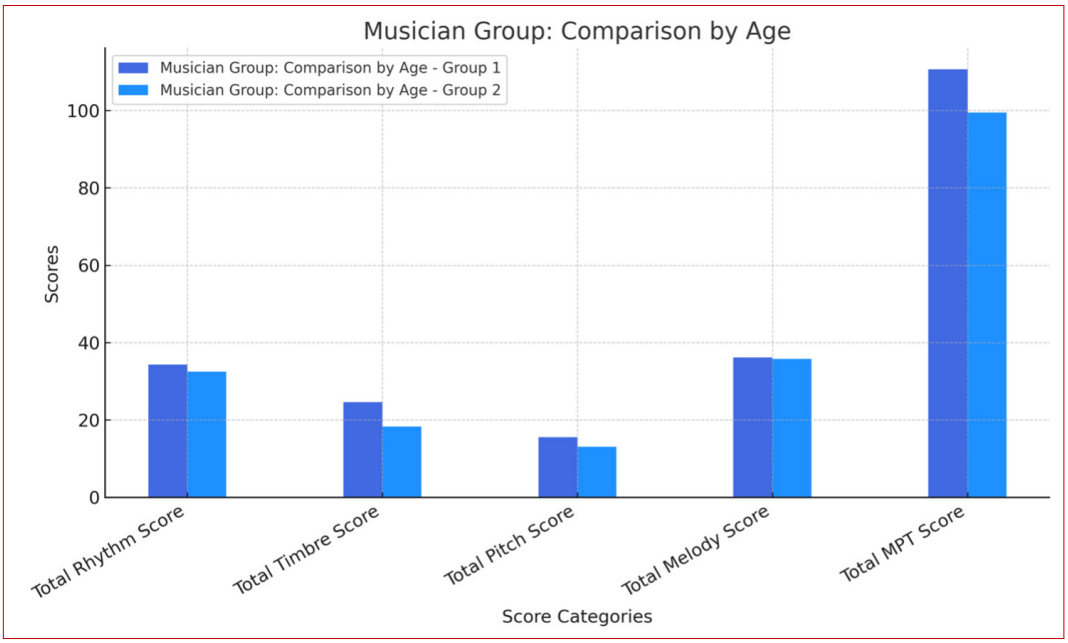
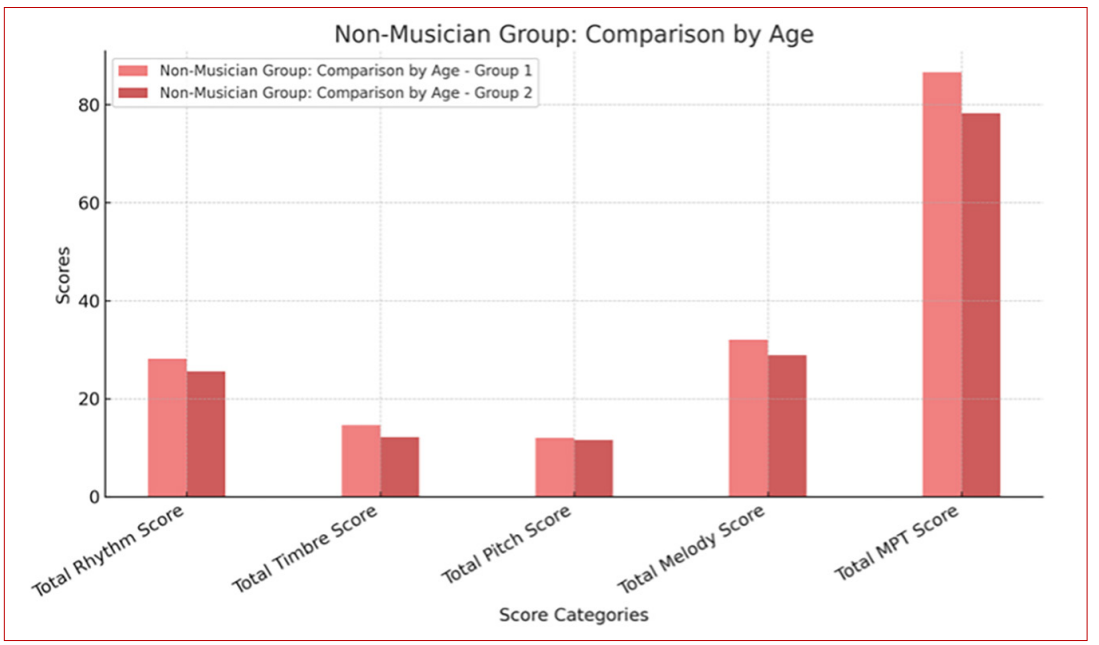


Table 3. Comparison of musical perception total scores by age group in non-musician group

Scores	Group	N	$\bar{X}$	SD	Z	P[1]
Total Rhythm Score	**45-64**	20	28.200	4.3115	-1.887	0.059
	65-85	20	25.600	4.1345		
Total Timbre Score	**45-64**	20	14.600	3.5894	-1.999	0.046*
	65-85	20	12.150	2.7003		
Total Pitch Score	**45-64**	20	12.000	1.9735	-0.691	0.490
	65-85	20	11.600	2.0875		
Total Melody Score	**45-64**	20	32.050	4.2485	-2.634	0.008**
	65-85	20	28.850	3.5581		
Total MPT Score	**45-64**	20	86.600	9.8054	-2.329	0.020*
	65-85	20	78.200	9.7203		

**p<0.05 *p<0.05 1:Mann Whitney U test $\bar{X}$:Mean SD:Standard Deviation

Figure 3. Comparison of musical perception total scores by age group in non-musician group



and non-musicians in all scores except those for pitch recognition, pitch discrimination, and total pitch ($p<0.05$). Although there were no significant differences in the pitch subtest and total pitch scores, musicians showed a significantly higher mean total MPT score than non-musicians across the education levels ($p<0.05$).

DISCUSSION

A musician's suprathreshold sound processing ability declines with age, just as it does for a non-musician. However, lifetime studies indicate that musicians have better auditory performance than non-musicians on a variety of psychoacoustic tasks because musicians exhibit higher levels of performance in frequency or temporal dimensions and speech understanding in noise (4). Previous studies have also shown that long-term music training and experience can cause neuroplastic, structural, and functional changes. Moreover, the effects of music education not only increase musical abilities but also improve various cognitive functions. Recent studies have highlighted the advantages of music training on cognitive functions, including speech perception (9), pitch perception (10), working memory (11), and attention in both auditory and visual modalities (12).

The effects of music education have been studied in detail due to its positive impact on perceptual and cognitive skills. Research has shown that music training improves performance, particularly in auditory tasks. For example, musicians have demonstrated a greater ability than non-musicians to detect silent gaps between sustained sounds, discriminate the duration of auditory events, and detect errors in synchronized rhythms (13,14). Musicians also outperformed non-musicians in their ability to understand speech in noisy environments, especially when presented with simultaneous auditory stimuli from different spatial locations. Intensive music training develops complex auditory skills related to music, such as speech, language, emotion recognition, and other auditory processing tasks. Studies have suggested

that good performance in these skills is a result of training rather than a genetic predisposition. (15) In addition to changes in perceptual performance, music training leads to changes in neuroplasticity. Neuroimaging techniques used in cross-sectional studies have revealed that music training is associated with neuroplastic changes in the auditory brainstem responses, auditory cortex, motor cortex, visuospatial brain regions, and high-level brain regions associated with working memory and executive functions (2).

In a validity and reliability study conducted by Şahlı et al. on 100 normal hearing individuals aged 18-40 years, the levels of education and interest in music significantly affected the MPT test results (8). In our study, it was found that there was a statistically significant difference between the mean levels of interest in music and frequency of listening to music according to the groups ($p<0.05$). The level of interest in music and the frequency of listening to music were higher in the musician group and there was a statistically significant difference in the MPT total score of the musician group compared to the non-musician group ($p<0.05$).

When the total musical perception scores of the participants were analysed according to their educational level, a statistically significant difference was observed in the MPT total score as the educational level increased ($p<0.05$). It is thought that with the increase in education level, general culture and cognitive skills such as learning and intelligence are positively affected and this increases the total test scores of musical perception. Our findings are consistent with those of previous studies and suggest a decrease in the MPT total score with advancing age. Testing across different age groups shows that aging affects the peripheral and central auditory systems, which is believed to affect both auditory perception and musical skills. However, the effect was less pronounced among musicians than non-musicians. Based on the results from controlling for musical perception skills between groups, it was hypothesized that being a lifelong musician may positively impact the auditory processing of the central auditory mechanisms.

Grassi et al. evaluated the auditory and visual memory of 40 individuals, including 20 musicians ($65 \leq$ age ≤ 84 years) and 20 non-musicians ($65 \leq$ age ≤ 84 years). The results of the auditory tasks revealed similar performances between musicians and non-musicians in pure-tone audiometry. In contrast, musicians performed better than non-musicians in terms of auditory processing abilities and frequency and duration discrimination skills. Regarding cognitive abilities, musicians performed better than non-musicians in complex working memory and visuospatial tasks, while the two groups did not differ in short-term memory measurements (16). Cohen et al. evaluated auditory and visual memory and demonstrated that musicians had superior auditory memory compared to non-musicians in terms of both musical and non-musical sounds (17). Consistent with the literature, our study showed a significant difference in the total MPT and subtest scores between musicians and non-musicians in the 65-85 age range.

Habibi et al. recorded the behavioral and event-related brain potential responses of musicians and non-musicians to rhythm differences between unusual melody pairs based on Western classical rules. Musicians detected rhythm deviations significantly better than non-musicians (18). In our study, the rhythm total score and subdomain scores of musicians were significantly higher than those of non-musicians.

Dubsky et al. examined whether 10 weeks of choral training using the QuickSIN (Speech-In-Noise) and the FDL (frequency difference limens) test could improve auditory processing and noisy speech perception in older adults. The results showed that choral singing may be used as an effective intervention to reduce age-related losses in auditory-perceptual abilities in as few as 10 weeks. More importantly, the intervention improved

older adults' ability to perceive speech in noisy environments (19). In another study, Parbery-Clark et al. investigated the effects of music training on noisy speech performance. Musicians exhibited better frequency discrimination and working memory than non-musicians and also outperformed non-musicians on both the QuickSIN and HINT (20). In our study, no significant differences were found in musicians by age group on the melody recognition subtest in noise, whereas a significant difference on the subtest was found in non-musicians by age group. The present findings show that music education can preserve auditory and musical perceptions despite advancing age. Finally, we believe that the ability to understand speech in the presence of noise, which deteriorates with age, can be preserved through music education.

The use of a cross-sectional design in this study limits the establishment of a causal relationship between the results. In addition, factors such as sample size and age group distribution may affect the generalisability of the findings. The fact that the participants' music education backgrounds were not differentiated in detail makes it difficult to consider additional variables that may affect the performance differences between the groups. In the future, it is recommended that similar research be conducted with longitudinal studies and larger sample groups.

The findings suggest that music education can preserve auditory and musical perception despite advancing age. These results may guide the development of music-based therapeutic approaches that can be integrated into interventions aimed at preserving cognitive and auditory functions in older adults. For example, the implementation of regular music education or music therapy programmes can be considered as effective interventions in supporting speech comprehension, working memory and other cognitive functions in noisy environments. In the future, the design and implementation of intervention studies will make important contributions to the literature in this field.

CONCLUSION

Studies show that music education can preserve auditory and musical perception despite advancing age. These findings reveal the potential benefits of integrating music-based interventions into auditory rehabilitation programmes for older adults. The ability to understand speech, especially in noisy environments, is one of the main challenges that older adults face in social communication and activities of daily living. Difficulties in speech comprehension in noise can lead to social isolation, communication disorders and a decrease in overall quality of life in older adults. Preservation of auditory processing and cognitive abilities supported by music education may help to reduce such difficulties.

The results of our study show that music education preserves auditory and musical perception skills despite advancing age.

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Declarations: Conflict of Interest: The authors declare no financial or nonfinancial conflicts of interest.

Ethical Approval: This study was approved by Istanbul Medipol University (ethical code E-10840098-772.02-3622). All the procedures were performed in accordance with the 2013 version of the 1964 Helsinki Declaration.

Previous Presentations: This study was presented at the IVth Otology and Audiology Congress (Online) held on 20-21 May 2023.

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