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Turkish dichotic sentence mobile scan test results in young and elderly people

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Abstract

Background This study investigated the impact of age on dichotic listening performance by comparing results from the Turkish Dichotic Sentence Mobile Screening Test in young and elderly individuals with normal hearing. A total of 60 adults (30 young, 30 old) underwent otoscopic examination, audiological tests, and, for the elderly group, a mini-mental test. The Turkish Dichotic Sentence Mobile Screening Test was administered, and directed and undirected scores for the right and left ears were compared between age groups.

Results In the young group, the directed left ear mean (96.67% ± 8.02%), directed right ear mean (98.33% ± 3.79%), undirected left ear mean (97.67% ± 6.26%), and undirected right ear mean (98.67% ± 5.71%) were obtained. In the elderly group, corresponding values were lower: directed left ear mean (49.00% ± 36.33%), directed right ear mean (54.67% ± 40.66%), undirected left ear mean (64.00% ± 32.86%), and undirected right ear mean (65.00% ± 30.82%). Statistically significant differences were found between the young and elderly groups ($p < 0.001$), with the young group consistently outperforming the elderly group.

Conclusions These results align with existing literature on dichotic listening tests, highlighting age-related declines in performance. The study contributes valuable insights into age-related changes in auditory processing and cognition, emphasizing the importance of considering dichotic listening as a marker of cognitive aging. Future research should explore potential interventions to mitigate age-related declines in dichotic listening performance.

Keywords Dichotic sentence test, Mobile application, Age effect, Dichotic listening, Auditory processing

Background

The American Speech-Language-Hearing Association (ASHA) recommends a comprehensive test battery approach encompassing both behavioral and objective assessments, including speech and non-speech tests, for diagnosing auditory deficits in individuals [2]. Dichotic tests, a crucial component in evaluating central auditory processing, involve presenting different speech stimuli simultaneously to both ears. These tests are considered highly sensitive to auditory cortex lesions. Previous literature has consistently observed a decline in dichotic test scores with increasing age, accompanied by an increasing advantage of the right ear over the left. Three plausible explanations have been proposed for this age-related phenomenon. Firstly, cognitive fas.

Dichotic tests, a crucial component in evaluating central auditory processing, involve presenting different speech stimuli simultaneously to both ears. These tests are considered highly sensitive to auditory cortex lesions. Previous literature has consistently observed a decline in dichotic test scores with increasing age, accompanied by an increasing advantage of the right ear over the left. Three plausible explanations have been proposed for this age-related phenomenon. Firstly, cognitive factors known to decline with age, such as memory and information processing strategies, may contribute to the observed decline in dichotic test performance [3, 4, 7]. Secondly, it

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has been hypothesized that the auditory pathways serving the left ear input may be more affected by aging than those serving the right ear input, leading to a relative decline in the function of the right hemisphere compared to the left [5, 10, 12]. Lastly, the loss of efficiency in interhemispheric transfer due to the degeneration of auditory pathways in the corpus callosum has been suggested as a third possibility [6]. Several studies, including those by Andrade et al. [1], Jerger et al. [9], Tawfik and Shafik [16], and Takio et al. [15], have investigated the relationship between age and dichotic test performance. These studies consistently report a decline in scores with increasing age, reinforcing the association between age and dichotic listening abilities.

In alignment with this body of research, our study focuses on investigating the effects of age on the results of the Turkish Dichotic Sentence Mobile Screening Test in individuals with normal hearing. The outcomes of our study align with existing literature, further substantiating the reliability of the mobile application in assessing dichotic listening abilities across age groups.

Methods

Ethical approval and consent to participate

Ethics committee permission for the study was received by the Uskudar University Non-Interventional Ethics Committee on 28/07/2021 with number 61351342. The participants included in the study were informed about the content and purpose of the study and their written consent was obtained.

Confirmation of participation

Written informed consent was obtained from the participants before starting data collection.

Study participants

Participants who were between the ages of 18 and 40 or 55 and 70 and were right-handed were included in the study. Inclusion criteria were individuals with normal peripheral hearing, no history or complaints of significant outer or middle ear disorders, and no neurological problems. The native language of all participants was Turkish. Participants in the elderly group with a standardized Mini Mental Test (SMMT) score of 24 and above were included in the study.

A total of 60 individuals were included in the study, including 30 young people between the ages of 18 and 40 and 30 adults between the ages of 55 and 70. While determining the sample size, the G Power 3.1.9.7 program was used and the *d* effect size was taken as 0.80 large and the analysis was made.

In this cross-sectional study, the primary aim was to investigate the influence of aging on central auditory processing skills, binaural interactions, and binaural processing skills utilizing the Turkish Dichotic Sentence Mobile Screening Test developed by Sevgi and Konukseven [13].

Turkish Dichotic Sentence Mobile Screening Test

The sentences used in the Turkish Dichotic Sentence Mobile Screening Test developed by Sevgi and Konukseven [13] were created by selecting the most used words on Google and the Word Frequency Dictionary of Written Turkish. After the sentences were created, they were transferred to the sentence pool. In total, 313 sentence data were collected in the sentence pool. The sentences collected in the data pool were recorded in the sound recording studio. The recorded voices were listened to, and the emphasized sentences were removed from the list. Thus, a total of 303 sentences remained in the audio recording. The sentences recorded by male and female speakers were recorded as a single audio recording.

In the Turkish dichotic sentence mobile screening test developed by Sevgi and Konukseven [13], sentences were created with 3 and 4 words. First, spectral analysis was applied to all sentences. The durations and frequency areas of the sentences were observed with spectral analysis. Sentences were added sequentially to the coherence analysis and pairs of sentences with similar frequency-intensity curves were determined. Sentences that are compatible and balanced with each other are presented dichotically to the individual in practice. Sentences reached both ears simultaneously and the duration of the sentence was set to 2 s. Afterwards, the individual participating in the test was given a response time of 12 s to respond. The test consists of four results: percentage of directed right and left ears and percentage of undirected right and left ears.

Procedure

Before initiating the test, participants were given a comprehensive introduction to the mobile application

Before initiating the test, participants were given a comprehensive introduction to the mobile application [13] and the dichotic sentence test (Supplementary Fig. 1). Clear instructions were provided, and participants were directed to conduct the test in a quiet environment. Upon downloading the application to smartphones with Android processors, participants were prompted to input their name, surname, gender, and age (Supplementary Fig. 1A). Each participant used their personal headphones, which were only used by them throughout the application and were compatible with their phones with 3.5-mm Jack input and Android processor. The participant was asked to wear the smartphone's headset correctly (the R symbol side of the headset to the Right ear

and the L symbol side to the Left ear). The sequence of test administration involved selecting the "Dichotic Sentence Identification Test" from the dichotic tests screen (Supplementary Fig. 1B). Subsequently, participants chose between male and female voice recordings (Supplementary Fig. 1C) and selected the level at which they heard the incoming stimulus most comfortably by sliding the button on the sound adjustment screen between 40 and 110 dB (Supplementary Fig. 1D). Prior to the test initiation, participants received informative letters to enhance their understanding of the study (Supplementary Fig. 1E). To facilitate adaptation, a practice test comprising 5 questions was administered. Participants were instructed to choose the correct sentence(s) based on the instructions given, with 20 s allotted for each question (Supplementary Fig. 1F). In total, participants answered 35 questions, including 5 practice questions. Following the completion of all procedures, the test's result evaluation screen was displayed (Supplementary Fig. 1G).

The testing process included a comprehensive introduction to the mobile application, practice sessions, and the completion of the main test consisting of 35 questions across various conditions. All the data collected in the study were entered into the Microsoft Office Excel program in detail. The data obtained in the research were analyzed using the SPSS 25.0 program. While evaluating the data, descriptive statistical methods (number, percentage, minimum–maximum values, mean, standard deviation) were used.

Cut-off scores for normative values were determined over the mean and standard deviation. Values 1.5 standard deviations above the mean were defined as normal, values between 1.5 and 2 standard deviations were defined as the limit range, and values below 2 standard deviations were defined as abnormal [11]. The normal distribution of the data was evaluated depending on whether the skewness and kurtosis values were between ± 3 [14]. An independent sample *t*-test was applied to the difference between two independent groups of quantitative data in normally distributed data. The significance level was accepted as 95%. In statistical analysis, the significance value was accepted as $p < 0.05$.

Table 2 Comparison of directed left ear, directed right ear, undirected left ear, and undirected right ear scores according to gender of young participants

	Gender	Mean ± standard deviation	*p*
Directed left ear	Female	98.00 ± 4.14	0.376
	Male	95.33 ± 10.6	
Directed right ear	Female	99.33 ± 2.58	0.155
	Male	97.33 ± 4.58	
Undirected left ear	Female	97.33 ± 7.99	0.776
	Male	98.00 ± 4.14	
Undirected right ear	*Kadın*	98.00 ± 7.75	0.532
	Erkek	99.33 ± 2.58	

* $p < 0.05$

Results

Turkish dichotic sentence mobile screening test was applied to a total of 60 individuals, including 15 (25%) young men, 15 (25%) young women, 15 (25%) old men, and 15 (25%) old women. Demographic information of the individuals participating in the study is given in Table 1.

The evaluation included 5 practice sentence pairs and 10 sentence pairs each for the directed right ear, directed left ear, and undirected tests, totaling 35 sentence pairs. Participants received 10 points for each correct answer and the results were scored as percentages. The directed right ear score, directed left ear score, undirected right ear score, and undirected left ear score were determined at the conclusion of the test.

The independent sample *t* test results applied to compare the directed left ear, directed right ear, undirected left ear, and undirected right ear scores according to the gender of the young participants are shown in Table 2.

Table 1 Demographic information of individuals included in the study

	Gender	*N*	Age Min	Age Max	Age Median	Age Mean ± standard deviation
Young	Male	15	18	32	26	24.06 ± 4.31
	Female	15	20	26	24	23.86 ± 2.19
	Total	30	18	32	25	23.97 ± 3.37
Old	Male	15	55	70	61	60.66 ± 4.32
	Female	15	55	70	56	57.80 ± 4.34
	Total	30	55	70	58.50	59.23 ± 4.50
Total		**60**	**18**	**70**	**43.50**	**41.60 ± 18.21**

There is no statistically significant difference between the directed left ear, directed right ear, undirected left ear, and undirected right ear scores of the young participants according to their gender ($p > 0.05$).

The independent sample *t* test results applied to compare the directed left ear, directed right ear, undirected left ear, and undirected right ear scores according to the gender of the elderly participants are shown in Table 3.

There is no statistically significant difference between the directed left ear, directed right ear, undirected left ear, and undirected right ear scores of the elderly participants according to their gender ($p > 0.05$).

Table 4 illustrates the outcomes of independent samples *t*-tests and the applied cut-off values for the comparison of directed left ear, directed right ear, undirected left ear, and undirected right ear scores between the young and old groups.

When comparing the directed and undirected ear scores of young and elderly participants according to their right and left ear status, in young participants, the difference between the right and left ear scores in the directed mode was 1.66%, and in the undirected mode the difference between the right and left ear scores was 1%. In elderly participants, the difference between right and left ear scores in the directed mode was 5.67%, and in the undirected mode, the difference between the right and left ear scores was 1%. However, no statistically significant difference was observed between directed/undirected total ear scores for the right and left ears in both young and elderly participants ($p > 0.05$). Moreover, the right and left ear total scores of young and elderly participants were compared based on their directed and undirected status. No statistically significant difference emerged between the ear scores of the young and elderly participants concerning their directed and undirected status ($p > 0.05$).

The results revealed that the directed left ear, directed right ear, undirected left ear, and undirected right ear scores of the young group surpassed those of the elderly group. This discrepancy was statistically significant, demonstrating a difference between the scores of the directed left ear, directed right ear, undirected left ear, and undirected right ear in the elderly and young groups ($p < 0.05$).

Table 3 Comparison of directed left ear, directed right ear, undirected left ear, and undirected right ear scores according to gender of elderly participants

	Gender	Mean ± standard deviation	*p*
Directed left ear	Female	56.67 ± 34.36	0.255
	Male	41.33 ± 37.77	
Directed right ear	Female	57.33 ± 44.96	0.726
	Male	52.00 ± 37.26	
Undirected left ear	Female	59.33 ± 36.15	0.446
	Male	68.67 ± 29.73	
Undirected right ear	Female	68.00 ± 31.89	0.603
	Male	62.00 ± 30.52	

* $p < 0.05$

Discussion

The results of our study shed light on the intricate interplay between age, gender, and dichotic listening performance, providing valuable insights into the dynamics of auditory processing. In the following discussion, we delve into the implications of our findings, drawing connections to existing literature and exploring potential avenues for future research.

The primary objective of this study was to apply the Turkish Dichotic Sentence Mobile Screening Test, developed by Sevgi and Konukseven [13], to both young individuals (aged 18–40) and elderly individuals (aged 55–70)

Table 4 Comparisons of directed left ear, directed right ear, undirected left ear, and undirected right ear scores according to the old/young groups

	Groups	Min	Max	Median	Mean ± standard deviation	*p*	Cut-off scores		
							Normal	Limit range	Abnormal
Directed left ear	Young	70	100	100	**96.67 ± 8.02**	**< 0.001***	> 84.6	80.6–84.6	< 80.6
	Old	0	100	40	**49.00 ± 36.33**		> −5.4	−23.6 to −5.4	< −23.6
Directed right ear	Young	90	100	100	**98.33 ± 3.79**	**< 0.001***	> 92.6	90.7–92.6	< 90.7
	Old	0	100	55	**54.67 ± 40.66**		> −6.3	−26.6 to −6.3	< −26.6
Non-directed left ear	Young	70	100	100	**97.67 ± 6.26**	**< 0.001***	> 88.2	85.1–88.2	< 85.1
	Old	0	100	80	**64.00 ± 32.86**		> 14.7	3.7–14.7	< −3.7
Non-directed right ear	Young	70	100	100	**98.67 ± 5.71**	**< 0.001***	> 90.1	87.2–90.1	< 87.2
	Old	0	100	75	**65.00 ± 30.82**		> 18.7	3.3–18.7	< 3.3

* $p < 0.05$

with normal hearing. The study aimed to investigate the impact of aging on central auditory processing skills, binaural interactions, and binaural processing skills. The utilization of the Turkish Dichotic Sentence Mobile Screening Test allowed for a contemporary approach to data collection, emphasizing the potential of mobile applications to enhance the accessibility and efficiency of auditory assessments [13]. This aligns with the broader trend in audiology towards leveraging technology for innovative diagnostic tools.

In comparison with similar studies, our findings align with the work of Andrade et al. [1], Jerger et al. [9], Tawfik and Shafik [16], Jerger and Martin [8], Jain et al. [7], and Takio et al. [15].

Like Andrade et al. [1], we observed that there was a negative correlation between age and correct response scores in both ears, with the worst performance occurring in the older group. Similarly, in line with Jerger et al. [9] and Tawfik and Shafik [16], our results indicate lower scores in the elderly group than in the younger group across various dichotic listening parameters.

Consistent with previous research, our study affirms the presence of age-related changes in dichotic listening, as evidenced by the significantly higher scores in directed left ear, directed right ear, undirected left ear, and undirected right ear among the young group compared to the elderly group [1, 9, 15]. The observed decline in performance among older individuals aligns with the broader consensus in the literature, which attributes these changes to factors such as cognitive decline, alterations in auditory structured pathways, and the efficiency of interhemispheric transfer [3–6, 10].

Jerger and Martin [8] observed that dichotic sentence definition test scores decreased with increasing age, aligning with our study where dichotic sentence mobile screening test scores exhibited a decrease with age. Takio et al. [15] reported the worst performance in the 59–79 age group, consistent with our findings where directed and undirected ear scores were lower in the elderly group.

Contrary to some existing literature, our study did not identify significant gender disparities in dichotic listening performance within either the young or old age groups [1]. The absence of a consistent pattern across genders suggests that other factors, such as individual cognitive and perceptual differences, may play a more prominent role in influencing dichotic listening outcomes. Further exploration of these individual differences could contribute to a more comprehensive understanding of the factors contributing to gender-related variations in dichotic listening.

While acknowledging these findings, it is crucial to consider potential limitations. Our study did not include groups with central pathology, and the sample size was relatively small. Future studies should aim for larger, more diverse samples, potentially incorporating individuals with central pathology, to enhance the generalizability of the results. One notable strength of our study lies in the application of the Turkish Dichotic Sentence Mobile Screening Test through a mobile app, providing a more accessible and natural testing environment compared to traditional methods.

The implications of our findings suggest potential avenues for future research, including the exploration of the test's applicability to individuals with hearing aids and cochlear implants, the development of mobile applications for illiterate or younger populations, and the integration of quality-of-life scales to assess environmental and daily life influences on test results. Despite the insights gained from this study, several limitations should be considered.

Conclusions

In conclusion, our study utilizing the Turkish Dichotic Sentence Mobile Screening Test provides valuable insights into the intricate interplay of age, gender, and ear-specific nuances in dichotic listening performance. The results reveal a significant age-related decline in dichotic listening skills, with younger individuals performing better than older individuals on several parameters. Interestingly, no significant gender disparities were observed. These findings underscore the importance of considering age-related changes in central auditory processing skills and binaural interactions. The study contributes to the existing literature by shedding light on the dynamics of dichotic listening and emphasizes the need for nuanced evaluation of ear-specific performance within different age groups. The observed decline in performance among older individuals aligns with broader cognitive and auditory structural changes associated with aging.

The implications of this research extend beyond academic realms, offering potential applications in clinical settings. The mobile assessment tool's ease of use and accessibility suggest its viability for broader implementation, making auditory assessments more inclusive and efficient. Future research efforts should address identified limitations, explore the test's applicability to diverse populations, and consider the broader implications of age-related changes in dichotic listening. Overall, this study contributes to advancing our understanding of auditory processing dynamics and opens avenues for further research in the evolving landscape of auditory assessments.

Abbreviations

ASHA American Speech-Language-Hearing Association
CAPD Central Auditory Processing Disorder
SMMT Standardized Mini Mental Test

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s43163-024-00595-4.

Additional file1: Supplementary Fig. 1. Interactive testing interface overview. A. Personal Information Screen: Users input their personal details before engaging in the auditory tests. B. Dichotic Tests Screen: This section presents users with dichotic listening tasks to assess their auditory processing abilities. C. Voice Selection Screen: Users choose between female and male voice recordings for the auditory stimuli. D. Volume Adjustment Screen: Illustration of the interface for adjusting volume settings, ensuring optimal test conditions. E. Informative Text Screens: Screens featuring relevant information to guide users through the testing process. F. Example Test Screens: Demonstrative screens showcasing the actual auditory tests users will encounter. G. Example Result Screens: Displays of result screens, providing users with feedback and insights based on their performance.

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Authors' contributions
SNT conceptualized and designed the study, conducted data collection and analysis, drafted and revised the manuscript, and approved the final version. OK led the project, provided guidance in the study design and execution, reviewed and contributed to manuscript drafts, and approved the final version. Both authors have made substantial contributions to the conception and design of the study, the analysis and interpretation of data, and the drafting and critical revision of the manuscript. They have read and approved the final version for submission and take full responsibility for the accuracy and integrity of the work.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was carried out as a Master's thesis in Istanbul Aydın University Graduate Education Institute Audiology Master's Program with Thesis. The permission to work was obtained by Uskudar University Non-Interventional Ethics Committee on 28/07/2021 with 61351342. Participants in the study were informed about the content and purpose of the study and their written consent was obtained.

Consent for publication
Written informed consent was obtained from participants included in the study for the publication of information on the Interactive Testing Interface Overview.

Competing interests
The authors declare that they have no competing interests.

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