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Investigation of the effect of age-related hearing loss on visual memory

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ABSTRACT

Aim: To investigate the effect of age-related hearing loss on visual memory.

Material and Method: 20 participants with normal hearing loss and 38 participants with hearing loss were included in the study. All of the patients were older than 65 years. Pure tone audiometry, speech audiometry and Benton visual retention test were applied to all participants.

Results: Mean Benton test score of the hearing-normal and the hearing loss group were 13.10±1.48 and 8.81±3.27 respectively. Patients were divided into three groups as hearing-normal, hearing loss with WRS greater than 80% and hearing loss with WRS lower than 80%. In terms of Benton scores there was statistically significant difference between groups ($p<0.001$). Post-hoc tests revealed that Benton scores of the group hearing loss with WRS lower than 80% were significantly low ($p<0.001$). Benton scores of hearing-normal and hearing loss with WRS greater than 80% groups were statistically similar ($p=0.075$).

Conclusion: Impairment of cognitive functions is related to dysfunction of higher order cognitive processes rather than sensory impairment.

Keywords: Word recognition score, dementia, Benton visual retention test

INTRODUCTION

Dementia is an important health problem that is very common worldwide. In recent years, there have been studies showing a link between age-related sensorineural hearing loss (ARHL) and dementia. (1-4) In a prospective cohort study, it was shown that age-related hearing loss is an independent risk factor for dementia and carries a higher risk than other possible risk factors (depression, social isolation, smoking, hypertension, and diabetes) (5). ARHL occurs degeneration in the cochlea and the auditory pathway (6,7). The relationship between cognition and sensory impairments has been studied for decades. These studies investigated whether the decline in cognition is due to hearing loss, whether the cognitive decline is due to hearing loss, or whether the two are associated with a common cause (8, 9). The aim of this study is to investigate the effect of age-related hearing loss on visual memory.

MATERIAL AND METHOD

The study was carried out with the permission of Yıldırım Beyazıt University Yenimahalle Training and Research Hospital Clinical Researches Ethics Committee (Date: 18.01.2023, Decision No: E 2022-65) All study processes were conducted under the principles of the Declaration of Helsinki and ethical rules. All participants provided written informed consent.

Study Design

Fifty-eight people over 65 years of age were included in the study. Of these participants, thirty-eight participants had sensorineural hearing loss, twenty participants had normal hearing loss (pure tone average better than 20 dB HL). All participants had normal or corrected-to-normal vision and no any otologic or neurologic diseases. Mini-Mental State Examination was applied to all participants and all participants scored over 24 points.

Audiometric Examination

A pure tone audiometry was administered to all participants using a pure tone manual diagnostic audiometer (Model GSI 61, Grason-Stadler, Inc.). The subjects were tested in a sound-isolated chamber, and pure tone audiometries were conducted at 0.125, 0.5, 1, 2, 3, 4 and 8 kHz using both air and bone conduction. The

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subjects were asked to discriminate between low sound levels of different frequency pure tones, and responded by pressing a button. The lowest tone heard at each frequency was considered as the hearing threshold level. Pure tone average (PTA) was calculated by averaging the hearing thresholds of 0.5, 1, 2, and 4 kHz. Speech audiometry was conducted after pure ton audiometry. Speech measures consisted of speech recognition thresholds (SRT), in dB hearing level (HL), and word recognition scores (WRS), in percent correct. The words presented via monitored live voice, were used for SRT and WRS.

Benton Visual Retention Test

Benton visual retention test procedure involves the presentation of a complex geometric figure that the participant must remember and later recall or reproduce. The version that was used in this experiment was similar to the multiple-choice administration of the BVRT in that for the recall portion of the test, the participants were presented a grid of four rotated and altered designs and were asked to select the correct design that had not been altered (10, 11).

Statistical Analysis

Data was analyzed using the SPSS version 21.0 software program (Statistical Package for Social Sciences v.21, IBM, Chicago, IL). The student t-test was used to compare continuous numerical variables between two groups. One way ANOVA test was used to compare continuous numerical variables between tree groups. Chi-Square test was used to investigate the association between categorical sex variables. A p-value < 0.05 was considered statistically significant.

RESULTS

Twenty subjects with normal hearing and thirty eight subjects with hearing loss were included in the study. The mean age of the hearing-normal group was 67.9±1.07 and the mean age of the hearing loss group was 68.52±2.12. There was no statistically significant difference in terms of ages between the two groups (0.279). Pure tone average (PTA) of hearing-normal group was 14.05±3.59 for right ear and 14.60 ±3.43 for left ear. Pure tone average (PTA) of hearing loss group was 50.57±11.02 for right ear and 49.39 ±10.71 for left ear. Mean word recognition score (WRS) of the hearing-normal group was 92.10±4.02 for right ear and 91.50 ±5.18 for left ear. Mean word recognition score (WRS) of the hearing loss group was 56.42±22.21 for right ear and 57.05±19.77 for left ear. There was statistically significant difference in terms of WRS between the two groups (<0.001 both ears) (**Table 1**). Mean Benton test score of the hearing-normal and the hearing loss group were 13.10±1.48 and 8.81±3.27 respectively (p<0.001). There was statistically significant difference in terms of Benton test scores between the two groups. Patients were divided into three groups as hearing-normal, hearing loss with WRS greater than 80% and hearing loss with WRS lower than 80%. In terms of Benton scores there was statistically significant difference between groups (p<0.001). Post-hoc tests revealed that Benton scores of the group hearing loss with WRS lower than 80% were significantly low (p<0.001). Benton scores of hearing-normal and hearing loss with WRS greater than 80% groups were statistically similar (p=0.075). (**Table 2**)

Table 1. The characteristics of hearing-normal group and hearing loss group.

	Hearing-normal group	Hearing loss group	p
Age (mean±SD)	67.9±1.07	68.52±2.12	0.279
Gender (F/M)	11/9	21/17	0.985
PTA, Right	14.05±3.59	50.57±11.02	<0.001
PTA, Left	14.60 ±3.43	49.39 ±10.71	<0.001
WRS, Right	92.10±4.02	56.42±22.21	<0.001
WRS, Left	91.50 ±5.18	57.05±19.77	<0.001

F: female; M: male; SD: standard deviation, PTA: Pure tone average; WRS: word recognition score

Table 2. The comparison of Benton test scores in groups

	Hearing-normal group, n=20	Hearing loss with WRS≥ 80%, n=16	Hearing loss with WRS <80%, n=22	p
Benton test score	13.10±1.48	11.75±2.21	8.47±3.22	<0.001

DISCUSSION

In this study, the relationship between age-related hearing loss and cognitive functions was examined by using the Benton visual retention test. The relationship between cognition and sensory impairment has been investigated by various previous studies and there are different theories about this issue. These studies investigated whether the decline in cognition is due to hearing loss, whether the cognitive decline is due to hearing loss, or whether the two are associated with a common cause.

The "sensory deprivation" hypothesis suggests that there may be cognitive Impairment at the neuronal level due to decreased adequate sensory input over an extended period of time (8). But cognitive impairment does not always occur after hearing loss. It has been known that there are also cognitive impairments with normal hearing. According to resource allocation hypothesis, or "information degradation" hypothesis, cognitive processes are restricted because of increased sensory impairments (14). Hearing loss increases the cognitive load and diverts cognitive resources to auditory processing at the expense of other cognitive processes such as working memory (15-16). In other words, people try to compensate their sensory deficits with cognitive resources such as working memory and attention. For

example, too many cognitive resources are used to understand speech and resources are reduced for higher order cognitive processes. Two hypotheses mentioned above suggest that cognitive decline may result from reduced sensory function.

Cognitive load on perception" hypothesis suggests that cognitive decline leads to sensory decline (8, 17). According to this theory, cognitive impairment can cause hearing loss. A fourth theory, known as the "common cause" hypothesis, suggests that common factor causes sensory and cognitive impairment (18,19). Cognitive and sensory impairment may be the result of a common causal mechanism such as age- related degeneration of the central nervous system.

Other alternative theory suggests that, performance on tests of cognition may be negatively affected as a direct result of sensory impairment (i.e. visual- and/or hearing-impairment) (20). It was reported that hearing impairment was associated with lower scores on a screening questionnaire for cognitive dysfunction (20).

In the current study, we aimed to evaluate the effect of ARHL on visual memory by using WRS and Benton visual retention test. Benton visual retention test measures visual perception and visual memory. Benton visual retention test is used a measurement of short-term visual memory storage and recall (10). Benton test requires "complex perceptual analytic ability and short-term memory retention. Cognition is typically measured through auditory means (i.e. verbal questions/ instructions that rely on hearing ability to be correctly interpreted). If hearing ability is not considered at the time of neurocognitive assessments, cognitive abilities may be underestimated because of limitations to perform on the test due to sensory impairment rather than cognitive deficits (11). Therefore, the Benton visual retention test was used in this study to evaluate cognitive functions.

In this study, word recognition scores were used in addition to hearing threshold for evaluating the central auditory functions instead of peripheral auditory system. Most research to date has focused on hearing sensitivity measured only on a peripheral level (i.e. audiometric thresholds only). It was contended that using tests of higher order listening function and collecting detailed information about the nature of the hearing loss may result in a greater understanding of whether there is a causal relationship between hearing and cognition.

In the current study, it was found that Benton scores of hearing-normal and hearing loss with WRS greater than 80% groups were statistically similar. This finding suggests that ARHL does not affect the cognitive function if WRS is greater than 80%. It can be said that, impairment of cognitive functions is related to dysfunction of higher order cognitive processes rather than sensory impairment.

CONCLUSION

In the light of findings of this study it can be said that Benton scores are affected by word recognition scores as a representation of high order cognitive functions.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Yıldırım Beyazıt University Yenimahalle Training and Research Hospital Clinical Research Ethics Committee (Date: 18.01.2023, Decision No: E 2022-65)

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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