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Auditory P300 in Elderly with Sensorineural Hearing Loss

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Abstract

Background: Hearing loss and cognitive impairment are common problems in older adults; several studies were conducted on the effects of hearing aid use relative to cognitive function in older adults. Most studies only used a verbal questionnaire which could lead to biased results. Therefore, the auditory P300 response from an electrophysiologic test provides an objective measure of central auditory function, including the cognitive process in the brain.

Methodology: A cross-sectional study was conducted from July, 2016 to April, 2017 at The Hearing Aid Clinic in Ramathibodi Hospital. Participants were 26 elderly patients with bilateral symmetrical sensorineural hearing loss who were referred for unilateral hearing aid fitting by ENT doctors. The auditory P300 test results and MMSE-Thai scores were recorded before and 2 months after hearing aid fitting.

Results: The P300 waveforms could be recorded from only 21 participants with a mean latency of 374.48 ms and mean amplitude of 6.68 μV. Two months after hearing aids were used, the mean P3 latency was 376.83 ms and the mean amplitude was 8.77 μV. There was a statistically significant difference in the amplitudes of P3 2 months after HA fitting (p=0.004). Moreover, the MMSE-Thai scores were also significantly higher (p=0.000).

Conclusion: The auditory P300 components could be recorded from approximately 80% of the sensorineural hearing loss elderly patients in this study. The auditory P300 results showed an improvement in cognitive ability with higher amplitude, corresponding to an increase in MMSE-Thai scores. Thus, the P300 may be used to evaluate the improvement in cognitive function after using a hearing aid. This outcome can be a guideline in counseling patients who initially rejected hearing aids on the benefits of using the hearing aids.

Keywords: Elderly; Sensorineural hearing loss; Cognitive ability; Hearing aid; Auditory P300 response

Introduction

The degree of change in organ systems occurs gradually with age [1] such as in the cardiovascular system, digestive system, endocrine system, skeleton system, respiratory system and nervous system. It is true that as age increases, there is a slight loss of neurons in the brain which affects all sensory systems because there are less neurons for proper function [2]. There is ample evidence pertaining to age-related reductions in the peripheral and central auditory systems, including cognitive abilities (e.g. the rapidity of information processing) [3,4].

Presbycusis is a Sensori-Neural Hearing Loss (SNHL) that occurs with increased age and often has no identifiable cause [5,6]. Beginning with a reduction in the perception of high frequency sounds and a progression toward lower frequencies, this loss might interfere with the ability to understand speech in a noisy environment or in group conversations and depends on the degree and types of individual hearing loss [7]. Furthermore, this condition can produce additional stress, reduce listening and speaking capabilities, and has an adverse effect on the quality of life [8]. Recent studies reported that reduced auditory input due to hearing loss is associated with a greater cognitive decline in the elderly than in those without hearing loss [9]. The prevalence of both hearing loss and cognitive loss increases with age. Therefore, it is reasonable to assume that cognitive problems are common in many older adults with hearing loss [4].

Hearing loss and cognitive impairment are common problems in older adults because they affect their quality of life [10,11]. These problems cannot be medically or surgically treated and hearing aids are commonly used for rehabilitation [5]. Some research studies reported that older adults benefited and demonstrated an improvement in their cognitive ability within 6 weeks after using a hearing aid [12].

There were a few studies conducted on the effects of hearing aid use relative to cognitive function in older adults. For example, Mulrow et al. reported improvements in cognitive function, after four months of hearing aid use, in an elderly group of subjects by using the Short Portable Mental Status Questionnaire (SPMSQ) [13]. Acar et al. also reported improvements in cognitive function after three months of hearing aid use in a group of older adults by using the Mini-Mental State Examination (MMSE) [5]. Both studies used a similar assessment method. However, only using a verbal questionnaire could lead to biased results because people may reply based on their own interpretation of each question and the bias of the interviewer who asked the questions and recorded their responses [14]. Therefore, an electrophysiologic test is recommended for assessing an improvement in cognition.

The auditory P300 response is an event-related potential that was first described by H. Davis in 1964 [15,16], which was evoked by use of an oddball paradigm stimulus that is associated with active mental processes in the brain such as attention, perception, memory, and cognition [17]. The subject is typically required to pay careful attention to the target stimulus and to respond to it by pressing a button or silently counting the number of target stimulus presentations [16,18-22]. This is an electro-physiologic test that provides an objective measure of central auditory function, including the cognitive process in the brain [23], which could be used to assess the cognitive function and avoid prejudice.

Material and Methods

Participants

Twenty-six participants were recruited from the Hearing Aid Clinic, Department of Communication Sciences and Disorders, Faculty of Medicine, Ramathibodi Hospital, Mahidol University. The study was approved by the Ethical Clearance Committee of the Faculty of Medicine, Ramathibodi Hospital, Mahidol University (ID 06-59-18) before collection of data. All of the participants were asked to sign an informed consent form to participate in the present study. The data were collected between July 2016 and April 2017. The inclusion criteria of the participants were being 60 years of age or older with bilateral symmetrical sensorineural hearing loss (Pure tone air-conduction average, over a 500-2000 Hz range, from 50 to 70 dBHL) and never having used a hearing aid before. Participants who had a history of outer and/or middle ear disorders and neurological and psychiatric diseases were excluded.

Instruments and procedures

1. All participants were asked to provide their personal data and medical history on the recording form.

2. Tympanometry and acoustic reflex tests were conducted using the GSI-Tymstar middle ear analyzer to exclude cases with middle ear pathology.

3. The auditory P300 was administered in a quiet room using the Intelligent Hearing System USB set during which the participant sat in a comfortable reclining chair. A two-channel electrode box was used for electrode placement following the international 10-20 system. Surface electrodes were attached at the low frontal midline (FpZ, ground electrode), the high frontal midline (Fz, active electrode), and the ear lobes (reference electrodes A1 and A2, left and right ear lobe respectively) with Ten20 conductive gel and micropore tape. Electrode impedances were maintained at 5 K ohms, with a maximum difference of 2 K ohms between electrodes, according to the test parameters recommended by the instrument company. The participants were instructed to press the button on a manual counter when they heard the rare stimuli within a series of standard stimuli. Trial training was conducted by presenting some stimuli to make sure that patients understood the task.

4. After completing the Auditory P300 test, participants were asked to take the MMSE-Thai (2002).

5. Unilateral hearing aid evaluation and fitting were provided to all participants according to the hearing aid fitting standard criteria and the patient's satisfaction. Each hearing aid was verified by probe microphone real ear measurement. After these patients chose the hearing aid they preferred, the researcher made ear impressions and scheduled an appointment with them during the following week to receive their hearing aids. Counseling and orientation sessions on hearing aid use were scheduled which emphasized that hearing aids should be used every day for at least 6 hours per day.

6. During the 2 months follow-up appointment after the hearing aid was fitted, all tests were repeated (Auditory P300 and MMSE-Thai).

Statistical analysis

All data were analyzed by using the IBM SPSS Statistics for Windows version 24. Descriptive statistics, including means and standard deviations, were used to calculate the auditory P300 results and MMSE scores before and after a hearing aid was used. Comparisons of the latency and amplitude of auditory P300, before and after a hearing aid was used, were made by using a paired samples t-test. Comparisons of the MMSE scores, before and after a hearing aid was used, were made by using the Wilcoxon signed-rank test. Statistical significance was indicated if $p \leq 0.05$.

Results

Demographic data

Twenty-six participants in this study were 13 male (50%) and 13 female (50%) elderly patients with sensorineural hearing loss. The participants' ages ranged from 60 to 87 years with a mean age of 73.4 ± 8.5 years. The participants' hearing levels in the ear that was anticipated for hearing aid use ranged from 52 to 70 dBHL (mean of 60 ± 5.2). The participants' duration of hearing loss ranged from 1 to 30 years (mean of 8.5 ± 8.0).

Results of the auditory P300 test

Eighty-one percent of the participants, 21 out of 26, produced satisfactory auditory P300 recordings before and after a hearing aid was used.

A comparison of the latency and amplitude values of the auditory P300 components (Table 1). The mean amplitude of auditory P300 after hearing aid use was higher than the mean amplitude of P300 before hearing aid use and the difference was significantly different ($t=-3.205$, $p=0.004$).

P300 results	Before HA		After HA		Paired t-test (t)	p-value
	Mean	SD	Mean	SD		
Latency (ms)	374.48	33.36	376.83	31.61	-0.437	0.667
Amplitude (μV)	6.68	4.91	8.77	2.11	-3.205**	0.004

Table 1: Results of the auditory P300 before and after hearing aids were used. ** Significant at p<0.01

Results of MMSE-Thai test

The MMSE-Thai was completed by all participants before and after hearing aids were used.

At the first test period (before using a hearing aid), the mean MMSE-Thai score was 21.62 ± 3.71. At the second test period (2 months after a hearing aid was used), the mean MMSE-Thai score was 24.21 ± 3.83.

The Wilcoxon signed-rank test was used to analyze the difference in the MMSE-Thai scores before and after the hearing aids was used. The analysis indicated that the mean MMSE-Thai score after hearing aids were used was significantly higher than before hearing aids were used (z=-3.935, p=0.000) (Table 2).

MMSE score	Before HA		After HA		Wilcoxon signed-rank test (z)	p-value
	Mean	SD	Mean	SD		
Latency (ms)	21.62	3.71	24.21	3.83	-3.935**	0.000

Table 2: Results of MMSE-Thai scores before and after hearing aids were used. ** Significant at p<0.01

Discussion

The auditory P300 response

The auditory P300 is comprised of event-related responses that are reflected in the human brain process as a cognitive function. The present study evaluated the changes in the cognitive abilities of elderly patients with SNHL who used a hearing aid for 2 months. The auditory P300 responses could be recorded for only 21 participants. Considering the factors that may affect auditory P300 responses, and which have been included in the present study, were the participant's age, degree of hearing loss, and duration of hearing loss. There were no significant differences in mean age, degree of hearing loss, and duration of hearing loss between the groups of participants who produced responses and those who did not produce responses on the auditory P300.

Regarding the group of 21 participants who produced an auditory P300 response, the researcher found that after 2 months of hearing aid use, the amplitude of P300 was significantly higher than before using a hearing aid. Therefore, the hypothesis that the P300 amplitude was a function of CNS activity that reflects the processing of information incorporate with memory representations of stimulus [24], may be related to this result. Furthermore, this result of the present study suggests possible neuroplasticity caused by the particular hearing aid used. According to the study of Cramer (2011), neuroplasticity occurs as a result of the nervous system's ability to reorganize its structures, functions, and connections in response to stimuli [25].

P3 latency is considered to be a measure of the ability of stimulus classification [26] and is generally unrelated to response selection processes [27,28]. In the present study, the P3 latency did not change significantly after 2 months of hearing aid use. Based on this result, it was concluded that the use of a hearing aid did not enhance the rapidness of information processing in the brain initially caused by advanced age.

Moreover, there was a non-significant correlation between the change in P300 amplitude and duration of hearing loss of each patient (r=-0.008, p=0.974). The findings of the present study agreed with those of Leite et al. [29], although the characteristics of their participants were different. Leite et al. included Long-Latency Auditory Evoked Potentials (LLAEPs), which included P1, N1, P2, N2, and P3 components, in their evaluations of the effects of hearing aid use relative to the cognitive functions of children with SNHL.

The MMSE-Thai test

The findings of this study showed that there were significant differences in the mean MMSE-Thai score before and after hearing aids were used during the 2 months period. Also, the mean score after use of a hearing aid was significantly higher than before use of a hearing aid. These findings were similar to those of Acar et al. [5] and MacDonald et al. [30].

In the study of Acar et al. their results indicated that the cognitive function of their subjects was significantly improved after 3 months of hearing aid use which was evaluated by using MMSE questionnaires [5].

Moreover, MacDonald et al. evaluated the effects of hearing aid use on the cognitive function of the elderly. The results of their study suggested that the use of a hearing aid increases auditory input and leads to significantly improved scores on the MMSE [30].

There are several limitations in the present study that need to be addressed. First is a small sample size, which might not reflect the actual outcomes of the entire population. Second, the follow-up duration of patients was too short and was not long enough to validate the results. Third, the instruments that were used to assess the cognitive function change may have been inadequate for this purpose.

A further study should be conducted with a larger sample size to confirm the effectiveness of hearing aid use for SNHL patients and to investigate the factors affecting the change in cognitive abilities. Moreover, a further study should extend the follow-up duration, such as 4 months or 6 months, to validate the results and to predict the improvements in cognitive functions after use of a hearing aid during each period of time. In addition, a further study should be conducted that include a more specific assessment of each domain of cognitive abilities and used a test that is strongly link with cognitive abilities, such as auditory Mismatch Negativity (MMN).

Conclusion

The findings of this study suggested that the cognitive function of elderly patients with sensorineural hearing loss can be improved after using a hearing aid for 2 months at least 6 hours per day every day. The study findings also indicated that these improvements occurred as a result of neuroplasticity in the brain and suggested that the auditory P300 can be used to assess the benefits of hearing aid use by elderly patients with sensorineural hearing loss.

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References

1. Weinstein BE (2012) The Biology of Aging. Geriatric Audiology: Thieme 15-47.
2. http://global.britannica.com/science/human-aging.

3. Tun PA, Williams VA, Small BJ, Hafter ER (2012) The Effects of Aging on Auditory Processing and Cognition. Am J Audiol 21: 344-350.
4. Pichora-Fuller MK (2015) Cognitive Decline and Hearing Health Care for Older Adults. Am J Audiol 24: 108-111.
5. Acar B, Yurekli MF, Babademez MA, Karabulut H, Karasen RM (2011) Effects of hearing aids on cognitive functions and depressive signs in elderly people. Arch Gerontol Geriatr 52: 250-252.
6. Weinstein BE (2012) The Aging Auditory System. Geriatric Audiology: Thieme 65-90.
7. Fioretti A, Poli O, Varakliotis T, Eibenstein A (2014) Hearing Disorders and Sensorineural Aging. J Geriatr 1-6.
8. Solheim J (2011) Hearing loss in the elderly: consequences of hearing loss and considerations for audiological rehabilitation [Dissertation]: University of Oslo.
9. Wong LL, Yu JK, Chan SS, Tong MC (2014) Screening of cognitive function and hearing impairment in older adults: a preliminary study. Biomed Res Int 1-7.
10. Dalton DS, Cruickshanks KJ, Klein BE, Klein R, Wiley TL, et al. (2003) The impact of hearing loss on quality of life in older adults. Gerontologist 43: 661-668.
11. Barrios H, Narciso S, Guerreiro M, Maroco J, Logsdon R,et al. (2013) Quality of life in patients with mild cognitive impairment. Aging Ment Health 17: 287-292.
12. Weinstein BE (2012) Sensory Management. Geriatric Audiology: Thieme 205-279.
13. Mulrow CD, Aguilar C, Endicott JE, Tuley MR, Velez R, et al. (1990) Quality-of-life changes and hearing impairment: A randomized trial. Ann Intern Med 113: 188-194.
14. http://libweb.surrey.ac.uk/library/skills/Introduction%20to%20Research%20and%20Managing%20Information%20Leicester/page_48.htm.
15. Davis H (1964) Enhancement of evoked cortical potentials in humans related to a task requiring a decision. Science 145: 182-183.
16. Sutton S, Braren M, Zubin J, John ER (1965) Evoked-potential correlates of stimulus uncertainty. Science 150: 1187-1188.
17. Coser MJ, Coser PL, Pedroso FS, Rigon R, Cioqueta E (2010) P300 auditory evoked potential latency in elderly. Braz J Otorhinolaryngol 76: 287-293.
18. Picton TW (1992) The P300 wave of the human event-related potential. J Clin Neurophysiol 9: 456-479.
19. Picton TW, Bentin S, Berg P, Donchin E, Hillyard SA, et al. (2000) Guidelines for using human event-related potentials to study cognition: recording standards and publication criteria. Psychophysiology 37: 127-152.
20. Hall JW (2007) New Handbook of Auditory Evoked Responses, Pearson.
21. Polich J (2007) Updating P300: An Integrative Theory of P3a and P3b. Clin Neurophysiol 118:2128-2148.
22. Duarte JL, Alvarenga KdF, Banhara MR, de Melo ADP, Sás RM, et al. (2009) P300- long-latency auditory evoked potential in normal hearing subjects: simultaneous recording value in Fz and Cz. Braz J Otorhinolaryngol 75: 231-236.
23. Reis ACMB, Frizzo ACF, Isaac Md L, Garcia CFD, Funayama CAR, et al. (2015) P300 in individuals with sensorineural hearing loss. Braz J Otorhinolaryngol 81: 126-132.
24. Polich J (1998) P300 clinical utility and control of variability. J Clin Neurophysiol 15: 14-33.
25. Cramer SC, Sur M, Dobkin BH, O'Brien C, Sanger TD, et al. (2011) Harnessing neuroplasticity for clinical applications. Brain 134: 1591-1609.
26. Polich J (1986) Attention, probability, and task demands as determinants of P300 latency from auditory stimuli. Electroencephalogr Clin Neurophysiol 63: 251-259.
27. McCarthy G, Donchin E (1981) A metric for thought: a comparison of P300 latency and reaction time. Science 211: 77-80.
28. Pfefferbaum A, Christensen C, Ford JM, Kopell BS (1986) Apparent response incompatibility effects on P3 latency depend on the task. Electroencephalogr Clin Neurophysiol 64: 424-437.
29. Leite RA, Magliaro FCL, Raimundo JC, Bento RF, Matas CG (2018) Monitoring auditory cortical plasticity in hearing aid users with long latency auditory evoked potentials: a longitudinal study. Clinics (Sao Paulo) 73: e51.
30. MacDonald AA, Joyson A, Lee R, Seymour DG, Soiza RL (2012) The effect of hearing augmentation on cognitive assessment scales at admission to hospital. Am J Geriatr Psychiatry 20: 355-361.