Original Article

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A Comparison Study of the Auditory P300 Results of Elderly Patients with Sensorineural Hearing Loss

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Abstract:

Objective: The purpose of this study was to compare the auditory P300 results of elderly patients with sensorineural hearing loss (SNHL) before and after hearing aid use.

Material and Methods: A cross-sectional study was conducted from July, 2016 to April, 2017 at the Hearing Aid Clinic of Ramathibodi Hospital. Twenty-six elderly patients aged ≥60 with bilateral symmetrical SNHL who were referred for unilateral hearing aid fitting by otolaryngologist were included. The auditory P300 was recorded before and 2 months after hearing aid fitting.

Results: The P300 waveforms, with a mean latency of 374.48 milliseconds and mean amplitude of 6.68 microvolts (μV), could be recorded in only 21 participants. At 2 months after hearing aid use, the mean P3 latency was 376.83 ms and mean amplitude was 8.77 μV. There was a statistically significant difference in amplitude of P300 2 months after hearing aid fitting (p-value=0.004).

Conclusion: The auditory P300 results indicate an improvement in cognitive ability with higher amplitude. Thus, the P300 may be used to evaluate improvements in cognitive function after using a hearing aid. It can also be used as a guideline for explaining the benefits of hearing aid use to patients who initially rejected a hearing aid.

Keywords: auditory P300 response, cognitive ability, elderly, hearing aid, sensorineural hearing loss

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Introduction

Presbycusis is gradually progressive sensorineural hearing loss (SNHL).[1] It is very common, occuming in approximately one-third of the population over 65 years of age.[2] Recent studies have reported that reduced auditory input due to hearing loss is associated with a higher degree of cognitive decline in the elderly than in those without hearing loss.[3] The prevalence of both hearing loss and cognitive loss increase with age. Therefore, it is reasonable to assume that cognitive problems are also common in many older adults, affecting their quality of life.[4,5] These problems cannot be medically or surgically treated. However, hearing aids are commonly used for rehabilitation.[6] Some research studies have reported that older adults could receive benefits and demonstrate their improvements in cognitive ability after using hearing aids for 6 weeks.[7]

Many research studies have been conducted on the benefits of using hearing aids that affect the cognitive abilities of older adults. For example, Mulrow et al. (1990)[8] reported improvements in cognitive function after 4 months of hearing aid use in an elderly group of subjects using the Short Portable Mental Status Questionnaire. Acar et al. (2011)[6] reported improvements in cognitive function after 3 months of hearing aid use in a group of older adults using the Mini-mental State Examination. Higher speech recognition scores after hearing aid use were also reported.[9,10] It can be seen that most studies often used a verbal questionnaire as a subjective method to evaluate the benefits of using hearing aids which may have led 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.[11] Therefore, an electrophysiologic test is recommended for assessing improvements in cognition.

The auditory P300 response has an event-related potential that was first described by Davis in 1964,[12,13] and evoked by the use of an oddball paradigm stimulus which is associated with active mental processes in the brain such as attention, perception, memory, and cognition.[14] In addition, the report of Polich in 1998 suggested that P300 amplitude was a function of central nervous system activity that reflects the processing of information incorporate with memory representations of stimulus.[15] In 1986 it was suggested that latency is considered to be a measure of the ability of stimulus classification.[16] 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.[13,17-21] This is an electrophysiologic test that provides an objective measurement of central auditory function, including cognitive processes in the brain.[22] Therefore, the purpose of this study was to compare the auditory P300 results of elderly patients with SNHL before and after hearing aid use.

Material and Methods

Ethical consideration

This study was approved by the Ethical Clearance Committee of the Faculty of Medicine, Ramathibodi Hospital, Mahidol University (ID 06-59-18) before data collection. All of the participants were asked to sign an informed consent form in order to participate in this study.

Study design and participants

The cross-sectional study was conducted from July 2016 to April 2017 at the Hearing Aid Clinic, Department of Communication Sciences and Disorders, Faculty of Medicine, Ramathibodi Hospital, Mahidol University. The 26 participants were 60 years of age or older with bilateral symmetrical SNHL (with a pure tone air-conduction average of 500-2,000 Hertz (Hz), range from 50 to 70 decibels hearing level (dBHL)) and had never used a hearing aid before. According to the personal medical records, participants who had a history of outer and/or middle ear disorders and neurological and psychiatric diseases were excluded.

Instruments

The instruments used in the present study consisted of the Grason-Stadler (GSI) Tymstar tympanometer and the Intelligent Hearing System Universal Smart Box (USB) set for auditory P300 response. First, the tympanometer was used to confirm that all the subjects did not have any middle ear pathologies. Second, the Intelligent Hearing System USB set was used. This is a computer program that is used for electrophysiologic testing.

Administration procedure

1. All participants were asked to provide their personal data and medical history in record form.

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

3. The auditory P300 test was conducted in a quiet room using the Intelligent Hearing System USB set, while 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 to 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 lobes, respectively) with Ten20 conductive gel and micropore tape. Electrode impedances were maintained at 5Kohms, with a maximum difference of 2Kohms between electrodes, according to the test parameters recommended by the instrument company, shown in Table 1. 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 they understood the task.

4. Unilateral hearing aid evaluation and fitting were done for every participant, according to hearing aid fitting standard criteria and the patient's satisfaction. Each hearing aid was verified by probe microphone real ear measurement. After that, patients chose the hearing aid they preferred and the researcher made an appointment with them during the following week to install their hearing

Table 1 The auditory P300 response test parameters

Parameters	Value
1. Transducer	ER 3A insert earphones with foam tips
2. Type of stimulus	500 (standard) and 1000 (target) Hz tone bursts
3. Rate of stimulus	1.1/sec
4. Type of Oddball paradigm	2- stimulus
5. Signal difference	Frequency difference
6. Probability	80:20 (standard:target)
7. Polarity	Alternating
8. Intensity	20 dB above the threshold for each frequency
9. Presentation ear	Monuaral
10. Amplification	100000x
11. Analysis time	500 ms
12. Sweeps	32 sweeps
13. Filters	1-30 Hz

ER=Etymotic Research, Inc., Hz=hertz

aid. Counseling and orientation sessions on hearing aid use, which emphasized that a hearing aid should be used for at least 6 hours per day, were scheduled.

5. During the 2-month follow-up appointment, after the hearing aid was fitted, the auditory P300 test was repeated without hearing aid.

Statistical analysis

All data were analyzed using the International Business Machines Statistical Package for the Social Sciences Statistics for Windows, version 24. Descriptive statistics including means and standard deviations, were used to describe the auditory P300 results before and after hearing aid use. Comparisons of the latency and amplitude of auditory P300 before and after hearing aid use were analyzed using a paired samples t-test. Statistical significance was indicated if p-value<0.05.

Results

Demographic data

The 26 participants in the present study were 13 males (50.0%) and 13 females (50.0%) with SNHL. Their ages ranged from 60 to 87 years with a mean age of 73.4±8.5 years. Their hearing levels, in the ear anticipated for a hearing aid, ranged from 52 to 70 dBHL (mean 60.0±5.2 dBHL). Their duration of hearing loss ranged from 1 to 30 years (self-reported) with a mean of 8.5±8.0 years. These characteristics are shown in Table 2.

Results of the auditory P300 test

Eighty-one percent of the participants (21 from 26) successfully completed the auditory P300 recordings before and after a hearing aid was used.

A comparison of the latency and amplitude values of the auditory P300 components is shown in Table 3. The amplitudes of the auditory P300 after hearing aid use were higher than the amplitudes of P300 before hearing aid use with a statistically significant difference (t=-3.205, p-value=0.004) but the latency difference was not significant (t=-0.437, p-value=0.667).

Table 2 Demographic characteristics of participants

Characteristics (n=26)	Values
Gender (male/female)	13/13
Age (years)	73.4±8.5
Hearing level (dBHL)	60.0±5.2
Duration of hearing loss (years)	8.5±8.0

dBHL=decibels hearing level

Table 3 The results of auditory P300 before and after hearing aid use

P300 results	Before HA		After HA		Paired t-test (t)	p-value
	Mean	S.D.	Mean	S.D.		
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

**significant at p-value<0.01

HA=hearing aid, S.D.=standard deviation, ms=millisecond, µV=microvolt

Discussion

The auditory P300 has an event-related potential that is reflected in the human brain process as a cognitive function.

In the present study, the changes in the cognitive abilities of elderly patients with SNHL who used a hearing aid for 2 months were evaluated. However, the auditory P300 responses could be recorded for only 21 participants (n=26). The factors that may affect the auditory P300 responses have been considered in this study, whether or not it is the participants' age, degree of hearing loss, or 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 auditory P300 responses, the researchers found that after 2 months of hearing aid use, the amplitude of P300 was significantly higher than before the use of a hearing aid. Therefore, the hypothesis that the P300 amplitude is a function of the central nervous system activity that reflects the processing of information incorporated with memory representations of stimulus[15] 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 et al. (2011)[23], neuroplasticity occurs as a result of the nervous system's ability to reorganize its structures, functions and connections in response to stimuli.

P3 latency is considered to be a measure of the ability of stimulus classification[16] and is generally unrelated to response selection processes.[24,25] In the present study, the P3 latency did not change significantly after 2 months of hearing aid use. For this result, it was assumed that the use of a hearing aid cannot enhance the rapidness of information processing in the brain caused by advanced age.

The findings of the present study agree with those of Leite et al.[26] 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 evaluation of the effects of hearing aid use relative to the cognitive functions of children with SNHL.

There are several limitations in the present study that need to be addressed. First, the small sample size might not reflect the actual outcomes of an entire population. Second, the follow-up duration was too short in order to fully verify the results.

A further study should be conducted with a larger sample size to confirm the effectiveness of hearing aid use by SNHL patients and to investigate other factors which affect the changes in their cognitive abilities. Moreover, a further study should have an extended follow-up duration, such as 4 months or 6 months, in order to verify the results and prognosticate the improvement of cognitive functions after the use of a hearing aid during each period of time. In addition, a further study should have a control group, paired by gender, age, type and degree of hearing loss, but not adapted with a hearing aid in order to prove whether the variability that occurred in P300 amplitude was actually due to the use of hearing aids. Lastly, a further study should use an assessment method that does not require cooperation from the participant, such as auditory mismatch negativity, because with the auditory P300 it is still necessary for the participant to pay attention carefully during the test.

Conclusion

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

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Conflict of interest

The authors declare that they have no competing interests.

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