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BRIEF REPORT

Preliminary normative variation of auditory P300 parameters in adult individuals

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Abstract

Background and Aim: Auditory P300 is an event-related potential. Cognitive factors like attention are involved in the generation of P300. It seems that normative variation of P300 is necessary for clinical purposes. Thus, the current study was designed to establish preliminary normative variation of P300 amplitude and latency at Fz and Cz sites in adults.

Methods: This cross-sectional study was performed on 20 right-handed volunteers aged 18 to 33 years. P300 was recorded monaurally with two channels at Fz and Cz placements. Two tone bursts of 1000Hz and 2000Hz were used as frequent and target stimuli, respectively.

Results: The mean values of P300 amplitude and latency at Cz were 7.43±2.61 µv and 325.19±21.34 ms in the right ear and 7.38±2.73µv and 320.29±21.56 ms in the left ear, respectively. At Fz, the mean values of P300 amplitude and latency were 5.34±1.74 µv and 330.09±25.58 ms in the right ear and 5.67±2.30 µv and 329.52±29.25 ms in the left ear, respectively. The differences between the ears at Cz and Fz were not statistically significant (p>0.05). The mean value of amplitude of P300 was significantly greater at Cz than Fz (p=0.001) although the difference in latency was not statistically significant between Cz and Fz (p>0.05).

Conclusion: Amplitude of P300 was greater at Cz than Fz although latency was not different. Based on these findings, amplitude and latency values can be probably used for clinical purposes to assess auditory disorders.

Keywords: Adult; P300; normal hearing; event related potentials

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Introduction

Auditory evoked potentials (AEPs) are electrical brain waves originated from auditory system that would be evoked by acoustical stimulation [1].

Event-related potentials (ERPs) are used to assess cortical region and also evaluate high-order cognitive processes. One of the most popular ERPs is Auditory P300 response [2]. Auditory P300 was first introduced in 1960s by Sutton et al. [3].

Cognitive factors such as attention are involved in the generation of this endogenous response [2].

Two tone burst stimuli are presented through oddball paradigm. They are composed of standard stimuli with more probability and lower frequency and target stimuli with lower probability and higher frequency. If a person is

focused on target stimuli through, for example, trying to count it, then P3b is possible to be recorded. Often, P3b is referred as P300 [4].

Various factors are involved in the generation of P300 including auditory discrimination, temporal processing, attention, and memory [5]. P300 is a useful tool for evaluating the effectiveness of medical, surgical, and even rehabilitation interventions in different groups (like Alzheimer patients, etc.) [6]. The exact origin of P300 is unknown, but it seems that anterior cingulate sulcus, frontal cortex, superior parietal cortex, inferior parietal cortex, and hippocampus may be involved [7]. Suitable and reliable placement of non-inverting electrodes for recording P300 is midline of head that includes Fz, Cz, and Pz [4,8,9].

From the view of age effects on P300, Steinschneider et al. concluded that P300 is not mature in children; by increasing age from childhood to adult, amplitude of P300 increased and latency decreased. Also, they pointed that P300 became mature in age range of 14-16 years [10]. In contrast, most studies showed that P300 is not affected by gender [11,12].

One of the major drawbacks of P300 is the lack of normative data that has been accepted generally. This may be one of the reasons for not extensive entry of P300 to the area of clinical field. In neurological disorders, usually P300 amplitude decreases and latency increases; thus, the aim of this study was to establish preliminary normative variation of P300 amplitude and latency parameters in normal hearing adults aged 18-33 years at Fz and Cz electrode placements. It is hoped that a better understanding will be achieved on the possibility of cortical regions involvement in different disorders by evaluating the obtained results in this study and comparing them with those of other disorders and pathologies.

Methods

This cross-sectional study was performed on 20 normal hearing individuals (15 male and 5 female) aged 18-33 years with mean and standard deviation of 24.25±4.65 at department of Audiology at School of Rehabilitation Sciences, Iran University of Medical Sciences (IUMS). To meet ethical consideration, the study was approved by the Ethics committee of Iran University of Medical Sciences with code number of IR.IUMS.REC 1395.9311301008. Also, all of the participants signed a written informed consent.

Inclusion criteria were: absence of any abnormality in external and middle ear, having normal hearing threshold (25 dBHL or better at 250-8000 Hz), being right-handed, having diploma degree or higher, not being in the menstrual cycle (for females), and lack of drowsiness. In order to reduce variability, participants' assessment was conducted in the morning. Case history and Edinburgh inventory were completed for all the participants. Then, otoscopy for examination of external auditory canal and tympanic membrane (Riester^{TM}), PTA with Hughson Westlake method (GSI audiometer, USA), typanometry and acousitic reflex (Madsen, Zodiac 901, GN Otometrics, Denmark) were employed. If the person was eligible for the inclusion criteria, then P300 would be performed.

An explanation for the test was given to all the subjects and if desired, the process of data collection was started. The participants could leave whenever they were unwilling to continue the study. P300 was administered with two channel Bio-logic Navigator® Pro (Natus Company, USA).

Lowering the impedance would result in better and reliable recording. Therefore, the spots of the skin where the electrodes were going to be placed were first cleaned. Then, non-inverting (+) electrodes were placed at Fz and Cz, inverting (–) electrodes at M1 and M2 (that were connected to each other through jumper lead), and ground electrode at Fpz. Stimuli were presented monaurally while the impedance of the electrode was 5 kΩ or less. Also, interelectrode impedance difference did not exceed 2 kΩ [4]. The rate of stimulation was 0.7. Two tone bursts of 1000 Hz (as standard stimuli with occurrence probability of 80%) and 2000 Hz (as target stimuli with occurrence probability of 20%) were used. The participants were

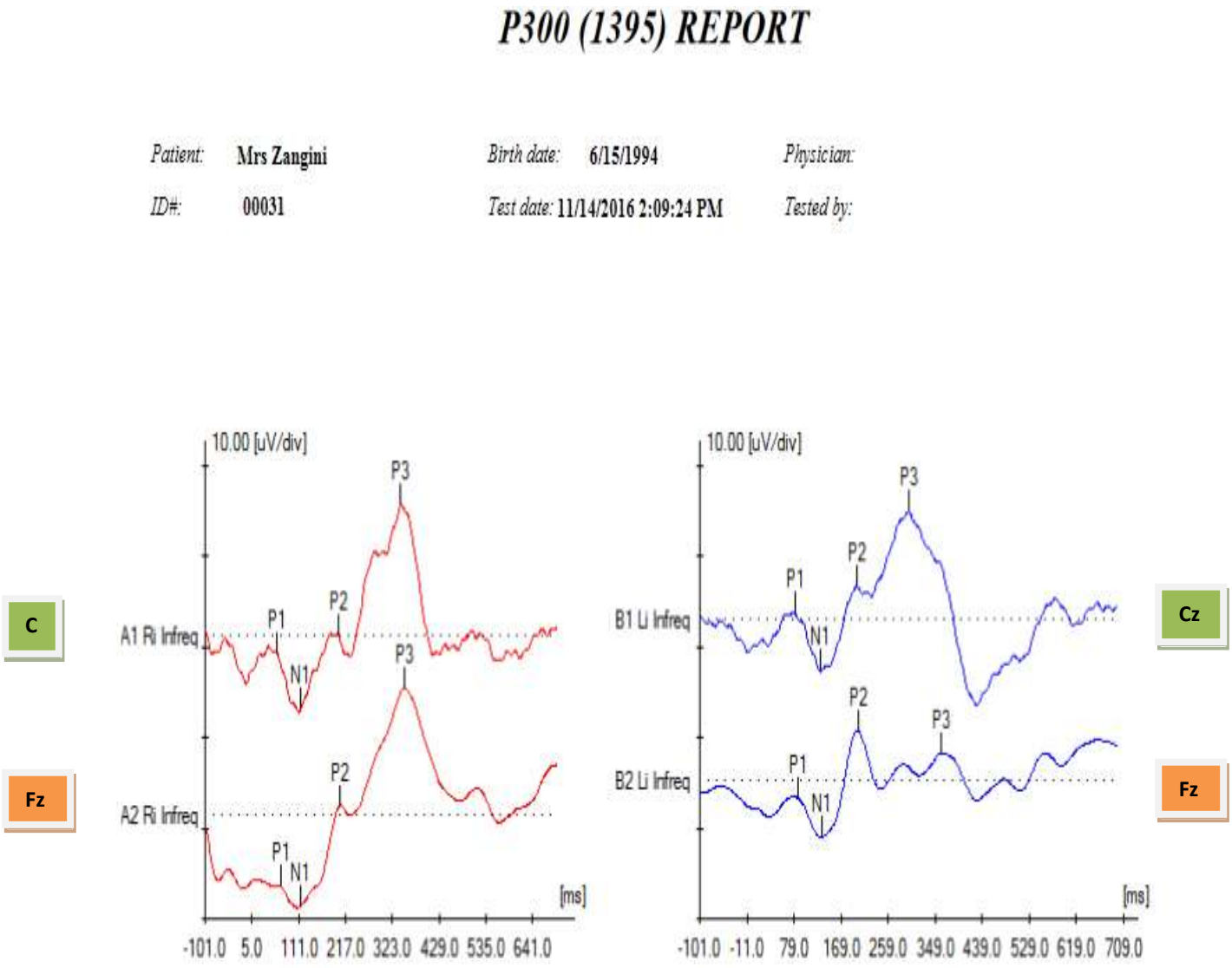

Fig. 1. A sample of P300 response recorded.

instructed to count only target stimuli in their mind [4].

To increase the validity of the test, the stimuli were first presented on a trial basis. Moreover, to enhance the reliability using the test-retest method, P300 was carried out in two trials. To remove artifacts caused by blinking eye movement, which would result in invalid responses and increased test time, the participants were instructed to open their eyes and focus on a dot in front of them.

For data analysis, we used IBM SPSS 21. First, the data were analyzed with Kolmogorov-Smirnov test. The result showed that variables had normal distribution. Paired t-test then was used to analyze the data. $p<0.05$ was considered statistically significant.

Results

A sample of P300 used in this study is shown in Fig.1. Table 1 indicates that at Cz placement, the mean value of P300 amplitude was 7.43±2.61 µv in the right ear and 7.38±2.73 µv in the left ear; analysis showed that the difference was not significant ($p>0.05$). Also, the mean values of P300 latency in the right and left ears were 325.19±21.34 ms and 320.29±21.56 ms, respectively. This implied that latency was

Table 1. P300 amplitude and latency in Cz and Fz placement by right and left ears of tinnitus (n=20)

Position		Right ear			Left ear			p
		Mean (SD)	Min	Max	Mean (SD)	Min	Max	
C_Z	Amplitude (μV)	7.43 (2.61)	3.2	11.64	7.38 (2.73)	3.17	12.66	0.89
	Latency (ms)	325.19 (21.34)	283.03	366.10	320.29 (21.56)	277.09	361.61	0.37
F_Z	Amplitude (μV)	5.34 (1.74)	3.05	9.85	5.67 (2.30)	3.03	11.91	0.51
	Latency (ms)	330.09 (25.58)	280.16	372.34	329.52 (29.25)	270.84	372.14	0.94

higher in the right ear although the difference was not significant ($p>0.05$).

At Fz placement, according to Table 1, the mean value of P300 amplitude was 5.34±1.74 μv in the right ear and 5.67±2.30 μv in the left ear. At this placement, the mean values of P300 latency were 330.09±25.58 ms and 329.52±29.25 ms in the right and left ears, respectively. However, the difference between the ears at Fz was not significant ($p>0.05$).

The mean value of P300 amplitude in the right ear was greater at Cz than Fz, which showed a significant difference ($p<0.001$). Also, the mean value of latency at Cz was lower than that of Fz although the difference was not significant ($p>0.05$).

In the left ear, the mean value of amplitude was greater at Cz than Fz, which showed a significant difference ($p=0.001$). In this ear, the mean value of latency at Cz was lower than that of Fz although no significant difference was observed.

Discussion

In the present study, we normalized the parameters of P300 such as amplitude and latency responses in normal hearing adults using Cz and Fz placements.

The ranges for amplitude (2-12 μv) and latency (270-372 ms) parameters of P300 were consistent with those of previous studies, for example, conducted by Steinschneider et al. [10], Polich et al. [11], Durret et al. [12], Fritzo et al. [13], Massa et al. [14], and Bennington and Polich [15], that reported the range of 2-22 μv for amplitude and 250-400 ms for latency.

In this study, there was no significant difference in latency between right and left ear. This finding is consistent with those of Fritzo et al. [13] and Massa et al. [14]. Kimura believed that there is some asymmetry between the two hemispheres in terms of verbal and non-verbal information processing, so that the right hemisphere is outstanding in non-verbal information (e.g. tone burst) than the left hemisphere [16]. As we know, left ear crosses to the left hemisphere; therefore, we expect to observe increasing amplitude and decreasing latency in obtained data from left ear [15]. However, in this study there was no significant difference between the two ears. Small sample size may be a reason for this observation. Our results are also in contrast to the findings of Li et al. [17].

Although P300 amplitude was larger at Cz than Fz, no significant difference was observed. These findings are consistent with those of Wronka et al. [7], Durate et al. [12], Frrizo et al. [13], Massa et al. [14], Bennington and Polich [15], and Polich [18]. It may be due to the placement of Cz electrode that was closer to the source of P300 production. These results are in agreement with the findings of many studies.

Considering that latency was shorter at Cz than Fz (but with no significant difference), this finding was in contrast to the findings of some researchers such as Bennington and Polich [15], and Mertens and Polich [19], who believed that

latency is shorter at Fz than Cz. One probable reason may be that first, their study was conducted to assess passive P3 components (P3a) whereas this study investigated P300 (P3b) and second, Cz was closer to the P300 response source than Fz. However, no significant difference in this regard may be due to the low number of samples.

Normalized amplitude and latency parameters found in this study can be used as cortical electrophysiological tools to evaluate high-level cognitive skills in neurological disorders (e.g. central auditory processing disorder), as well as in monitoring the treatment process and determining the effectiveness of rehabilitation programs such as auditory training.

Among the strengths of this study is the uniform distribution of the samples in terms of age, right handedness, and normal hearing. But in terms of weakness of the study, it can be mentioned to the low sample size and number of electrode placements. Therefore, we recommend researchers utilize more placement points and larger sample sizes in future studies.

Conclusion

According to the obtained results in this study, there was no significant difference in latency and amplitude of P300 between right and left ear. Also, probably due to being closer to the P300 response source, amplitude was significantly larger at Cz than Fz, while latency was shorter at Cz than Fz although the latter difference was not significant.

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