International Journal of Otorhinolaryngology and Head and Neck Surgery
Ramteke BB et al. Int J Otorhinolaryngol Head Neck Surg. 2020 Oct;6(10):1867-1873
http://www.ijorl.com
pISSN 2454-5929 | eISSN 2454-5937

DOI: http://dx.doi.org/10.18203/issn.2454-5929.ijohns20204191

Original Research Article

Latency and amplitude of P300 using speech and non-speech stimuli - a normative study

Bhimraj B. Ramteke*, Sushil N. Meshram

Department of ENT, Tata Main Hospital, Jamshedpur, Jharkhand, India

Received: 30 July 2020
Revised: 08 September 2020
Accepted: 09 September 2020

***Correspondence:**
Dr. Bhimraj B. Ramteke,
E-mail: bhimrajram@gmail.com

ABSTRACT

Background: The P300 was among the first auditory response in a collection of events related or endogenous evoked responses. The P300 is related to cognition and use of knowledge about the environment.
Methods: The subjects (n=60) selected with an equal distribution of genders. P300 evoked potentials elicited by non-speech and speech stimuli is recorded.
Results: There is a significant difference in latency of P300 for speech verses non-speech stimuli as well as there is a significant difference in the latency of P300 among males and females for speech versus non speech stimuli. No significant difference in amplitude of P300 for speech versus non-speech stimuli and for right versus left ears.
Conclusions: P300 latency is influenced by stimulus used and gender variation. The present study showed that the non-speech stimuli had lower latencies compared with speech stimuli. For the P300 amplitude values, the difference between groups were not significant.

Keywords: Auditory evoked response, Event-related potentials, P300, Latency, Amplitude

INTRODUCTION

An auditory evoked response (AER) is activity (a “response”) within the auditory system (the ear, the auditory nerve, or auditory region of the brain) that is produced or stimulated (“evoked”) by sounds (“auditory” or acoustic stimuli).[1] Depending on which sensory system is being stimulated, the evoked potentials (EP) may be referred to as an auditory evoked potential (AEP), visual evoked potential (VEP), or somatosensory evoked potential (SSEP). For example, in the auditory system, further categorization may include the brainstem auditory evoked potential (BAEP), the middle latency auditory evoked potential (MAEP), and the long latency auditory evoked potential (LAEP). Event related potential (ERPs) are endogenous. Earlier auditory evoked potential is considered exogenous because their characteristics are generally determined by external stimuli (i.e. an auditory signal such as a click or tone burst). For, e.g. ABR. In contrast, later auditory evoked potentials generally classified as endogenous potentials because they are primarily influenced by internal cognitive processes. For e.g. P300 response, which is the result of an individual’s recognition that a different stimulus has been presented. The event related potentials are subject to significant variation from both extrinsic and intrinsic factors. As a result of these variations, establishing a normative database requires precise specification of the stimuli. These include recording conditions; environment, subject state (including age, gender, various biological and psycho-physiological factors) and response task.[2]

Starr and Don and McPherson and Starr have proposed four variations in the classification of auditory evoked potentials:[3,4] 1) The latency of response (when they occur within the nervous system, i.e., early, middle, late). 2) The presumed generator (where they occur within the nervous system, i.e., cochlear, auditory nerve, brainstem, cerebral). 3) The temporal features (how they respond to auditory stimulation, i.e. transient, sustained or steady-state). 4) Dependence on stimulus or subject factors (endogenous, exogenous).

The P300 was among the first auditory response in a collection of events related or endogenous evoked responses.[5] A largest positive wave occurring at about 220 msec to 300 msec and whose amplitude of approximately 12 μV was related to the probability of the stimulus. The P300 is related to cognition and use of knowledge about the environment.[6,7] It is bimodal, having an "a" and "b" components. The P300a does not appear to be related to any mental or motor response and hence may be recorded without specific patient participation, although attention is a factor. The P300b is related to the task involved in the detection of the target stimuli and becomes more robust with target response.[8] Tones are the most common stimuli used in obtaining the P300 and are the least preferred yet the most simplistic as such tones do not provide as much information about neural function and processing as does speech and speech-like stimuli. The P300 has been found useful in the study of memory, memory disorders, sequential information processing, and decision making. The amplitude of the P300 is modulated by two sub-events such as their probability and meaning of the task involved in the detection of the acoustic stimuli.[9]

The aim of present study was to establish a comparative and normative latency and amplitude of P300 using speech stimuli and non-speech stimuli in normal hearing sensitivity population across the age range of 18 years to 30 years in 60 samples.

Objectives

To find out the gender differences in latency and amplitude of P300 for speech versus non-speech stimuli and to develop normative data of P300 for IHS instrument using speech stimuli.

Hypothesis

There is no significant difference in the latency of P300 for speech versus non speech stimuli.

There is no significant difference in the amplitude of P300 for speech versus non speech stimuli.

There is no significant difference in the latency of P300 among males and females for speech versus non speech stimuli.

There is no significant difference in the amplitude of P300 among males and females for speech versus non speech stimuli.

METHODS

The study was conducted at 'Department Of ENT, Tata Main Hospital Jamshedpur Jharkhand India' for a duration of 2 years from July 2018 to June 2020. It's a 'Prospective Randomized control trial' for comparative analysis of normative data. Ethical clearance was taken from 'Ethics committee for post graduate studies Tata Main Hospital'.

Inclusion criteria

Subjects of both sex between the age group 18 to 30 years with normal hearing sensitivity (i.e. PTA≤20 dBHL) and ABG≤10 dBHL using AC-40 dual channel audiometer. Subjects have no history of otological and/or neuro-otological pathologies with normal ear/otoscopic examination and impedance audiometry. Subjects were without any impairment of cognitive function.

Exclusion criteria

Subjects above 30 years and below 18 years, with PTA thresholds above 20 dBHL. and ABG more than 10 dBHL, withor without known ontological or neurotological disease with or without cognitive impairment were excluded.

A sample size of 60 subjects (n=60, male 30 and female 30) selected for the study from the outpatient pool of patients and were randomly allocated in two groups. The sample size was calculated using a two tailed hypothesis design formula with superior design model testing for a duration of 2 years, and with level of significance at 5 %, 80 % power and 1:1 allocation. An equal distribution of genders was taken to compare statistically.

For normative values of latency and amplitude of P300 using speech and non-speech stimuli Intelligent Hearing system Smart EP version 3.54 used. Voluntary written consent was taken from each subject and explained about the length of testing time. First for non-speech stimulus, subjects were presented with stimuli, which were of two-tone oddball paradigm nature. The target stimulus (infrequent/deviant/rare stimuli) was presented at an intensity level of 70 dBHL at 2 KHz. The baseline stimulus (frequent stimuli) was presented at an intensity level of 70 dBHL at 1 KHz. After the acquisition of P300 for non-speech stimuli. Second acquisition of P300 was done for the speech stimuli. Here, the same subject was presented with stimuli, which were of two-speech oddball paradigm in nature. The target speech stimulus /da/ (infrequent/deviant/rare stimuli) was presented at an intensity level of 70 dBHL at 2 KHz. The baseline speech stimulus /pa/ (frequent stimuli) was presented at an intensity level of 70 dBHL at 1 KHz. The target stimuli were presented randomly, and it constituted 20% of the total given stimuli. Subject was asked to focus his/her attention on the infrequent stimuli from that of the base line stimuli. The study was considered successful if the count and the number target stimuli matched.

Data entry was done with statistical package for social science (SPSS IBM version 21.0). Required test of significance such as chi square and independent test applied at $p<0.05$.

RESULTS

Data was obtained for event-related potentials P300 for latency and amplitude using speech and non-speech stimuli which was subjected to statistical analysis using descriptive and t-test analysis (2 tailed t-test, $p>0.05$ significance means no significant difference; $p\leq0.05$ significance means significant difference. The mean values of latency and amplitude of P300 using speech and non-speech stimuli for left and right ear with their standard deviation is presented in (Table 1).

Hypothesis 1

The mean P300 latency of right ear using non-speech stimuli was 300.72 msec (SD=24.769) while for speech stimuli was 337.50 msec (SD=25.958). For left ear, mean P300 latency using non-speech stimuli was 310.57 msec (SD=25.557) while for speech stimuli was 346.38 msec (SD=26.576) (Table 2). The 2-tailed significant shows value of 0.000 and 0.000 which indicated that there is a significant difference in latency of P300 for speech verses nonspeech stimuli (Table 8).

Table 1: The mean and SD values of latency and amplitude for P300 using speech and non-speech stimuli for right and left ears.

P300	Mean values		Standard deviation (SD)	
	Latency (msec)	Amplitude (µV)	Latency (msec)	Amplitude (µV)
Non-speech stimulus P300 right ear	300.72	13.924	24.769	1.5052
Non-speech stimulus P300 left ear	310.57	13.8268	25.557	1.3138
Speech stimulus P300 right ear	337.5	13.864	25.958	1.4342
Speech stimulus P300 left ear	346.38	13.8102	26.576	1.2761

Table 2: The mean P300 latency in right and left ears for speech verses non-speech stimuli.

	P300 latency	N	Stimuli	Mean P300 latency (msec)	SD
Pair 1	Latency right ear (msec)	60	Non-speech	300.72	24.769
			Speech	337.5	25.958
Pair 2	Latency left ear (msec)	60	Non-speech	310.57	25.557
			Speech	346.38	26.576

Table 3: The mean P300 amplitude in right and left ears for speech and non-speech stimuli.

	P300 amplitude	N	Stimuli	Mean amplitude (µV)	SD
Pair 3	Right ear (µV)	60	Non-speech	13.924	1.5052
			Speech	13.864	1.4342
Pair 4	Left ear (µV)	60	Non-speech	13.8268	1.3138
			Speech	13.8102	1.2761

Hypothesis 2

The mean P300 amplitude of right ear using non-speech stimuli was 13.924 µV (SD=1.5052) while for speech stimuli was 13.864 µV (SD=1.4342). For left ear, mean P300 amplitude using non-speech stimuli was 13.8268 µV (SD=13.8268) while for speech stimuli 13.8102 µV (SD=1.27610) (Table 3). The standard deviation for amplitude of right and left ears using speech and non-speech stimuli was not high, thus indicative of no variability in the ears. The 2-tailed significant for the right ear amplitude was 0.637 µV and for left ear amplitude was 0.938 µV (Table 8). This shows that there is no significant difference in amplitude of P300 for speech versus non-speech stimuli.

Hypothesis 3

In males, calculated mean latency in right ear using non-speech stimuli was 300.87 msec (SD=24.497) and using speech stimuli was 340.43 msec (SD=27.694) while calculated mean latency in left ear using non-speech stimuli was 307.63 msec (SD=26.632) and using speech stimuli was 349.17 msec (SD=28.718) (Table 4). On independent sample test, 2-tailed significance showed the value of 0.000 for right ear latency and 0.000 for left ear latency in males. In females, calculated mean latency in right ear using non-speech stimuli and speech stimuli was 300.57 msec (SD=25.455) and 334.57 msec (SD=24.210) respectively while calculated mean latency in left ear using non-speech stimuli and non-speech stimuli was 313.50 msec (SD=24.531) and 343.60 msec (SD=24.418) respectively (Table 5). On independent sample test, 2-

tailed significance showed the value of 0.000 for right ear latency and 0.000 for left ear latency in females (Table 9). The above statistical values indicated that there is a significant difference in the latency of P300 among males and females for speech versus non-speech stimuli (Table 9).

Table 4: The mean P300 latency in right and left ears in males speech verses non-speech stimuli.

	Males latency	N	Stimuli	Mean P300 Latency (msec)	SD
Pair 1	Latency right ear (msec)	30	Non-speech	300.87	24.497
			Speech	340.43	27.694
Pair 2	Latency left ear (msec)	30	Non-speech	307.63	26.632
			Speech	349.17	28.718

Table 5: The mean P300 latency of right and left ears in females for speech verses non-speech stimuli.

	Females latency	N	Stimuli	Mean P300 Latency (msec)	SD
Pair 1	Latency right ear (msec)	30	Non-speech	300.57	25.455
			Speech	300.57	24.21
Pair 2	Latency left ear (msec)	30	Non-speech	313.5	24.531
			speech	343.6	24.418

Table 6: The mean P300 amplitude of right and left ears in males for speech verses non-speech stimuli.

	Males amplitude	N	Stimuli	Mean Amplitude (µV)	SD
Pair 3	Amplitude right ear (µV)	30	Non-speech	13.982 (a)	1.7622
			Speech	13.982 (a)	1.7622
Pair 4	Amplitude left ear (µV)	30	Non-speech	13.933	1.3616
			Speech	14.221	1.0833

Table 7: The mean P300 amplitude of right and left ears in females for speech verses non-speech stimuli.

	Females amplitude	N	Stimuli	Mean Amplitude (µV)	SD
Pair 3	Amplitude right ear (µV)	30	Non-Speech	13.866	1.223
			Speech	13.745	1.024
Pair 4	Amplitude left ear (µV)	30	Non-Speech	13.7202	1.2785
			Speech	13.3993	1.3379

Hypothesis 4

In males, the mean P300 amplitude of right ear using non-speech stimuli was 13.982(a) µV (SD=1.7622) and for speech stimuli was 13.982(a) µV (SD=1.7622). For left ear, mean P300 amplitude using non-speech stimuli was 13.9330 µV (SD=1.36162) and for speech stimuli was14.2210 µV (SD=1.08337) (Table 6). On independent sample test, 2-tailed significance showed the value of 0.357 for left ear amplitude while a correlation and t cannot be computed for right ear amplitude because the standard error of differences is 0 in males (Table 10). The above statistical values indicate that there is no significant difference in the amplitude of P300 among males for speech versus non-speech stimuli. In females, the mean P300 amplitude of right ear using non-speech stimuli was 13.866 µV (SD=1.2235) and for speech stimuli was 13.745 µV. (SD=1.0248). For left ear, mean P300 amplitude using non-speech stimuli was 13.7202 µV (SD=1.27857) and for speech stimuli was 13.3993 µV (SD=1.33796) (Table 7). The standard deviation for amplitude of right and left ears using speech and non-speech stimuli was not high thus indicative of no variability in the ear. The 2-tailed significant value for the right ear amplitude was 0.641 µV while for left ear amplitude was 0.278 µV. This shows that there is no significant difference in amplitude of P300 for speech versus non speech stimuli (Table 10).

The maximum number of patients had a preoperative diagnosis of colloid goiter, followed by lymphocytic thyroiditis. The least number of patients had malignancy as their preoperative diagnosis (Figure 2). There were only two cases of revision thyroidectomies implying that the surgeons opted out of capsular dissection and went for nerve demonstration in such cases.

Table 8: Shows significance difference in latency and nonsignificant difference in amplitude in right and left ears for speech and non-speech stimuli.

	P300 latency	t	df	Sig. (2tailed)
Pair 1	Non-speech stimulus Lat. P300 right - speech stimulus Lat. P300 right	-11.165	59	.000
Pair 2	Non-speech stimulus Lat. P300 left - speech stimulus. Lat. P300 left	-9.712	59	.000
Pair 3	Non-speech stimulus Ampl. P300 right - speech stimulus Ampl. P300 right	0.475	59	0.637
Pair 4	Non-speech Sti. Ampl. P300 left - speech Sti. Ampl. P300 left	0.078	59	0.938

Table 9: Shows significance of latency in right and left using speech and non-speech stimuli.

	Males latency	t	df	Sig. (2tailed)
Pair 1	Non-speech stimulus Lat. P300 right - speech 0stimulus Lat. P300 right (latency right ear (msec)	-8.218	29	0.000
Pair 2	Non-speech Sti. Lat. P300 left - speech Sti. Lat. P300 left (latency left ear (msec)	-7.401	29	0.000
	Females Latency			
Pair 1	Non-speech stimulus Lat. P300 right - speech stimulus Lat. P300 right (latency right ear (msec)	-7.519	29	0.000
Pair 2	Non-speech Sti. Lat. P300 left - speech Sti. Lat. P300 Left (latency left ear (msec)	-6.478	29	0.000

Table 10: Shows significance of amplitude in right and left ears for male and female using speech and non-speech stimuli.

	Males amplitude	t	df	Sig. (2tailed)
Pair 3	Amplitude right ear (µV)	0	0	0
Pair 4	Non-speech stimulus Ampl. P300 left - speech stimulus Ampl. P300 left amplitude left ear (µV))	0.935	29	0.357
	Females amplitude			
Pair 3	Non-speech stimulus Ampl. P300 right - speech stimulus Ampl. P300 right amplitude right ear (µV)	0.472	29	0.641
Pair 4	Non-speech stimulus Ampl. P300 left - speech stimulus Ampl. P300 left amplitude left ear (µV)	1.107	29	0.278

DISCUSSION

Geal-Dor, Kamenir, Babkoff studied the event related potentials (ERPs) and behavioral responses and compare of tonal stimuli to speech stimuli in phonological and semantic tasks while they were performing three different tasks, using an oddball paradigm.[12] The first task was tones in which subjects were instructed to respond to a 1 KHz tone, and ignore a 2 KHz tone; second task was phonological in which subjects were instructed to respond only to pseudowords that had a specific ending (“f"), and third was semantic in which subjects were instructed to respond to words that belonged to a specific category (animals). EEGs were recorded from 19 electrode sites. Peak amplitude of the early component (N100) did not differ significantly across the three tasks, although N100 peak latency differed significantly across tasks. In contrast, the later endogenous component (P300) was stimulus-and task-dependent. P300 latency differed significantly across stimuli and tasks. It was 336ms to target tones; 682 ms to the phonological targets; and 727 ms to target words in the semantic task. P300 amplitude was significantly larger to tones than to speech stimuli. P300 peak amplitude recorded from electrode sites over the left hemisphere to the tonal target stimuli did not differ significantly from that recorded over the right hemisphere. In contrast, P300 amplitude recorded to both the phonological and semantic targets was significantly larger over the left hemisphere than over the right hemisphere at the parietal electrodes. Webster, Hedrick studied the auditory event-related potentials (Mismatch negativity and P300) and behavioral discrimination were measured to synthetically generated consonant-vowel (CV) speech and nonspeech contrasts in 10 young adults with normal auditory systems. The CVs were 2 within-category stimuli and the non-speech stimuli were 2 glides whose frequency ramps matched the formant transitions of the CV stimuli.[13] Listeners exhibited better behavioral discrimination to the nonspeech versus speech stimuli in same/different and oddball behavioral paradigms. MMN responses were elicited by the non-speech stimuli but absent to CV speech stimuli. Larger amplitude and earlier P300s were elicited by the non-speech stimuli, while smaller and longer latency P300s were elicited by the speech stimulus contrast. Results suggested that the 2 types of stimuli were processed differently when measured behaviorally, with MMN, or P300. The better discrimination and clearer neurophysiological representation of the frequency glide, non-speech stimuli versus the CV speech stimuli. Lew, Slimp et al studied the comparison of speech-evoked Vs tone-evoked P300 response in implications for predicting outcomes in patients with traumatic brain injury shows that the P300 response is a cognitive event-related potential recorded over the scalp.[14] The rare speech signal was the word "mommy" in a female voice. The common signal was a 1000-Hz tone. Speech-evoked P300 responses had significantly larger amplitudes (mean, 12.1 μV) than the tone-evoked responses (mean, 5.9 μV; $p<0.0001$). Polich and Martin studied the P300 (P3) event-related brain potential (ERP) elicited with auditory stimuli in a large random sample (n=54) of university undergraduates, with equal numbers of each gender assessed.[15] Grade point average was correlated negatively with P3 latency. Overall female subjects produced larger P3 amplitudes compared to males. The results suggested that normal undergraduate subjects do not produce strong changes in P3 measures as a function of specific cognitive capabilities or personality variation.

In the present study findings are the mean P300 latency of right ear using non-speech stimuli was calculated to be 300.72msec (SD=24.769) and for speech stimuli was 337.50msec (SD=25.958). For left ear, mean P300 latency using non-speech stimuli was 310.57msec (SD=25.557) and for speech stimuli 346.38msec (SD=26.576). In males, calculated mean latency in right ear using non-speech stimuli was 300.87msec (SD=24.497) and using speech stimuli was 340.43msec (SD=27.694). Similarly, calculated mean latency in left ear using non-speech stimuli was 307.63msec (SD=26.632) and using speech stimuli was 349.17msec (SD=28.718). In females, calculated mean latency in right ear using non-speech stimuli was 300.57msec (SD= 25.455) and using speech stimuli was 334.57msec (SD=24.210). Similarly, calculated mean latency in left ear using nonspeech stimuli was 313.50 msec (SD= 24.531) and using speech stimuli was 343.60 msec (SD=24.418).

CONCLUSION

The obtained data was analyzed using descriptive statistics and test of significance (p=0.00). The statistical results were manipulated as per the objectives of the study. The data was analysed in terms of latency and amplitude of P300 with respect to males, females, right and left ears using speech and non-speech stimuli. The 2-tailed significant shows value of 0.00 and 0.00 which indicated that there is a significant difference in latency of P300 for speech verses non-speech stimuli as well as males verses females. Therefore, Hypothesis 1 and 3 is rejected. The standard deviation for amplitude of right and left ears using speech and non-speech stimuli as well as the amplitude among males and females for speech versus non-speech stimuli was not high, thus indicative of no variability. Hence, Hypothesis 2 and 4 is accepted. This shows that there is no significant difference in amplitude of P300 for speech versus non-speech stimuli.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Hall JW. Handbook of auditory evoked responses. Allyn & Bacon. 1992.
2. McPherson DL. Late Potentials of the Auditory System. San Diego, California: Singu Publish Gro Inc. 1996;1128-34.
3. Starr AR, Don MA. Brain potentials evoked by acoustic stimuli. Human event-related potentials: EEG handbo. 1988;3:97-157.
4. Walker L. Late auditory evoked potentials as electrophysiological indices of behavioral discrimination. East Carolina University; 2005.
5. Sutton S, Braren M, Zubin J, John ER. Evoked-potential correlates of stimulus uncertainty. Scien. 1965;150(3700):1187-8.
6. Gibson EJ. Principles of perceptual learning and development.
7. Baars BJ. Contrastive phenomenology: A thoroughly empirical approach to consciousness. The nature of consciousness: Phiolosophical controversies. 1997: 187-202.
8. Michalewski HJ, Rosenberg C, Starr A. Event-related potentials in dementia. Frontiers of clinical neuroscience. 1986;3:521-8.
9. Johnson Jr R. The amplitude of the P300 component of the event-related potential: Review and synthesis. Advances in psychophysiology. 1988;3:69-137.
10. Kaga K, Kodera K, Hirota E, Tsuzuku T. P300 response to tones and speech sounds after cochlear implant: a case report. Laryngos. 1995;101(8):905-7.
11. Kaufman MJ, editor. Brain imaging in substance abuse: research, clinical, and forensic applications. Springer Science & Business Media. 2000.
12. Geal-Dor M, Kamenir Y, Babkoff H. Event related potentials response: comparison of tonal stimuli to speech stimuli in phonological and semantic tasks. J Basic Clinic Physiol Pharmacol. 2005;16(2-3):139-55.

13. Tampas JW, Harkrider AW, Hedrick MS. Neurophysiological indices of speech and nonspeech stimulus processing. J Spee Langua Heari Resear. 2005.
14. Lew HL, Slimp J, Price R, Massagli TL, Robinson LR. Comparison of speech-evoked v tone-evoked p300 response: implications for predicting outcomes in patients with Traumatic Brain Injury1. Americ J Physic Medic Rehabilitat. 1999;78(4):367-71.
15. Polich J, Martin S. P300, cognitive capability, and personality: A correlational study of university undergraduates. Personality Individual Differences. 1992;13(5):533-43.

Cite this article as: Ramteke BB, Meshram SN Latency and amplitude of P300 using speech and non-speech stimuli - a normative study. Int J Otorhinolaryngol Head Neck Surg 2020;6:1867-73.