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Original Research Article

Auditory P300 in Typical Individuals: Age and Gender Effect

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ABSTRACT

The present study aimed at investigating cognitive abilities of typical adults and older adults with normal hearing using P300 event related potential. The P300 measures (both latency and amplitude) did not differ significantly across gender. The P300 latency was found to increase with age, whereas the P300 amplitude reduced significantly with age except in the case of 60-70 years age group. Overall, the P300 measures reflected the ageing effect. Further, the choice of P300 which uses evoked potential (objectively extracted) and language insensitive stimuli can be made to evaluate cognitive linguistic functions in individuals with impaired communication abilities from different linguistic backgrounds.
Keywords- ageing, P300, latency, amplitude, cognition, event related potential

INTRODUCTION

Aging is defined as "a persistent decline in the age-specific fitness components of an organism due to internal physiological degeneration". [1] Aging characterizes a universal, progressive, and intrinsic decline after reproductive maturity. [2] The classification of aging varies across the world. Aging occurs typically in 60 to 65 years in developed countries, but in some developing countries where life expectancy is lower, the initiation of old age is much lower. [3] The process of aging affects communication. With increase in age, there is also increase in the incidence and prevalence of communication disorders. Older adults make up the majority of case load. [4] The position statement indicates that by 2020, the number of people over 60 years of age will exceed 1,000 million of whom 700 million will live in developing countries. [5] The study of hearing, speech and language issues in aging individuals is particularly important for the Audiologists and Speech-Language Pathologists.

Assessment of Cognitive Processing in Aging Individuals

A variety of approaches are used to study the cognitive processing in aging individuals. A few of these approaches are purely behavioral and require active participation of the subject. Physiological approaches on the other hand are purely laboratory based. A few of the physiological approaches which have gained immense popularity for assessment of cognitive processing include the Event Related Potentials (ERPs), Functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), and Doppler technique.

Event Related Potentials (ERPs)

The ERPs are very small voltages generated in the brain in response to specific events or stimuli. [6] The ERPs are thought to reflect the summed activity of post-synaptic potentials produced when a large number of similarly oriented cortical pyramidal neurons (in the order of thousands or millions) fire in synchrony while processing information. [7] The auditory evoked potentials obtained in humans are of two types: (a) the early potentials, or components peaking roughly within the first 100 milliseconds after the presentation of the stimulus, which are termed as "sensory" or "exogenous" because they depend largely on the physical parameters of the stimulus, and (b) the late potentials which reflect the manner in which the subject evaluates the stimulus and are termed "cognitive" or "endogenous" ERPs as they reflect on information processing. [8] The waveforms are described according to latency, amplitude and morphology.

The ERPs reflect the early cognitive functioning and hence can be useful research tool in evaluating the cognitive functioning in specific clinical population such as schizophrenia and older individuals. These potentials are also useful in evaluating the effect of cognitive training on the cognitive functioning. There are various endogenous potentials such as P300, N400, and P600.

Auditory P300 Potential

The most prominent of the ERPs is the P300. This has been linked to the amount of attentional resources allocated to the task. [9] The P300 is a long latency event related endogenous potential. [8] There are some of the pre-requisites for P300, which include a general latency expectation of around 300 ms. and optimal electrode array over the midline for recording the response with maximum amplitude. [9] It has been reported that P300 with greater amplitude is obtained with lower probability for the rare signal. [10] The P300 is used as an objective method for evaluation of cognition and can be generated by any form of stimulus; however the auditory oddball paradigm is the most commonly used. [11]

There are several variants of the oddball task which can be used to elicit P300. [12] The subject is instructed to respond either mentally or physically to the target stimulus and not otherwise. A few task situations involve response for both the standard as well as target stimuli. A robust P300 is obtained when the infrequently occurring target is successfully discriminated from the frequently occurring standard stimuli. This response appears as a large (5 to 20 μV) wave, usually the third positive component (P3) in the region of 300 ms. The P300 component is measured by checking its amplitude (μV) and latency. The measured amplitude is either peak amplitude between mean baseline voltage and largest positive peak or peak-to-peak amplitude from N2 of late latency response as a trough to the largest positive peak. On the other hand, latency (in ms) is defined as time from the stimulus onset to the occurrence of the largest positive peak within the time window decided by factors such as stimulus modality, age of the subject, task conditions and others.

P300 in Aging individuals:

Age is the most important variable affecting the latency of P300. The P300 latency has a significant positive correlation with age while the amplitude shows a significant negative correlation with age particularly in persons greater than 40 years of age. [11,13] Several studies have showed a positive correlation of age with P300 latency while there are conflicting reports with regard to correlation between age and P300 amplitude. [14,15] Similarly, larger N1 and P2 amplitudes are reported for elderly individuals as compared to younger individuals. [16,17] A few have attributed this to tendency of elderly individuals deploying compensatory mechanisms while listening in quiet situations. [18] There is an increase in mean latency by approximately 1.5 ms. per year and the standard error of estimate (SEE) was 20 ms. [15] Further, latency increase of 1.3 ms. per year after the age of 20 years was noted. [15]

Meta-analysis of studies on the effects of aging on P300 potential has been carried out. [19] A clear effect of aging on P300 amplitude and latency was observed. However, there was considerable variability among the reported studies with respect to different age groups, which was attributed to differences in methodology (number of subjects, gender, age-range, intellectual level, hearing status, general health, etc), task (counting vs. button-pressing response) and stimulus parameters. On an average, the P300 latency was reported to increase from 300 to 450 ms. from age 10 to 90 years, while the amplitude decreased at an average rate of 0.2 μvolt per year. A few studies have reported increase in variability of P300 with increase in age. [20] These authors recorded P300 response in only 52% of 232 subjects above 60 years of age. The authors suggested that the age-related change in hearing sensitivity was a factor in effecting decreased occurrence of P300 response with increase in age.

The relation between EEG findings and the auditory P300 response was investigated on 120 typical individuals in the age range from 20 to 80 years. There was a positive correlation between EEG spectral power and P300 amplitude. No such correlation was found between EEG spectral power and P300 latency. [19]

Apart from the increase in latency and decrease in amplitude of P300 with aging, studies have also reported an interaction between aging and scalp topography. [21] The reason however for the age-related scalp distribution is not clear. The authors found the strongest relationship between age and changes in P300 latency and amplitude for central / parietal electrode sites (Cz & Pz) and weaker relationship for midline Fz site and lateral electrode locations.

A study recruited 32 healthy male participants to study the effects of age on P300 potential and simultaneously acquired blood oxygenation level dependent (BOLD) signal of fMRI. Auditory oddball paradigm was used and functional MRI data were acquired in synchrony to the task. The results of the study indicated an age effect on P300 amplitude. Younger subjects demonstrated increased parietal P300 amplitudes and increased BOLD responses in a network of brain regions. Diminished neural responses in older adults compared to younger subjects especially in frontal, temporo-parietal and subcortical brain regions were noted. [22] The effects of age and gender on cognitive functions as assessed by P300 potential are also studied. The results of the study showed that the latencies increased and the amplitude decreased in the consecutive age-groups. There was no significant difference between males and females. The authors concluded that the increasing latencies of P300 indicate a subtle decline in cognitive function with increase in age. [23] Significant decline in short-term memory and slowdown of information processing is reported in elderly individuals with normal hearing than young subjects in behavioral studies. [24] However, verification of the same using ERPs is difficult due to greater variability compared to the sensory evoked potentials. [25, 26]

Need for the Study

The experimental procedure of P300 employs cognitive resources such as attention, memory, organization, executive functioning and problem solving skills. With an intention of building more evidence regarding the efficacy of P300 in tapping the cognitive processing, this study was undertaken. The present study was therefore formulated to compare the performance of typical adults and typical older adults (both with normal hearing sensitivity) for stimuli presented through auditory channel in selected tasks using P300, with the intention of understanding the gender and age-related changes, if any, in processing the auditory signals.

Aim of the Study

The study aimed at assessing the cognitive processing of adults and older adults with normal hearing using auditory P300 event related potential (latency and amplitude) across gender and age groups.

MATERIALS AND METHODS

Participants: A total of 70 participants were included. Group I consisted of typical adults in the age range from 20 to 40 years;

divided into two sub-groups; Group IA (N=20) with participants in the age from >20 to ≤ 30 years, and Group IB (N=20) with participants in the age from >30 to ≤ 40 years. Group II consisted of older adults with normal hearing, in the age range from 50 to 70 years; divided into two sub-groups; Group II A(N=20) with participants in the age from >50 to ≤ 60 years and Group II B (N=10) in the age from >60 to ≤ 70 years. Ethical clearance was obtained from AIISH Ethical Committee and the ethical guidelines for bio behavioural research involving human subjects were followed. [27] Informed consent was obtained from all the participants of the study before collection of data.

Participant Selection Criteria: The selection of participants was based on the following criteria: 1) Participants having normal hearing as tested with pure-tone through air-conduction i.e., < 25 dB HL at 500, 1000, 2000 and 4000 Hz. [28] 2) Participants having bilateral symmetrical hearing with not more than 10 dB difference between the ears. [29] 3) Participants having no abnormalities in speech and language abilities, neurological, sensory-motor, cognitive and behavioral aspects as tested on WHO disability screening checklist and informal assessment. [30] 4) Participants were native speakers of Kannada language; and able to read and write in Kannada (officially recognized language of Karnataka state of India).

Equipment: The following equipment were used to carry out the study: 1) Otoscope for visual examination of the external ear in order to rule out any contraindications for carrying out audiological evaluations. 2) A calibrated two-channel diagnostic audiometer to obtain the pure-tone air-conduction and bone-conduction thresholds. 3) A two-channel auditory evoked potential system was used to record P300 auditory evoked potentials and record the latency and amplitude measures.

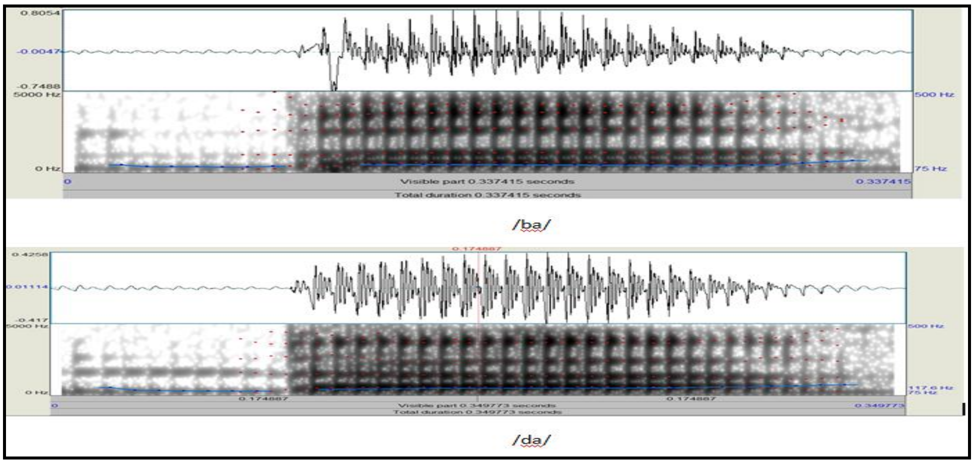


Figure 1: Waveforms and spectrograms of /ba/ and /ḍa/ syllables used for P300.

Stimuli for P300: The naturally produced and recorded CV tokens (/ba/ and /ḍa/) were incorporated in an "auditory oddball" paradigm in which a low-probability CV token (/ḍa/) was embedded in a stream of high probability CV token (/ba/). The /ba/ is a bilabial voiced plosive whereas /ḍa/ is a voiced retroflex plosive, The stimulus sequence in this auditory oddball paradigm consisted of /ba/ syllable with a frequency of occurrence of 80% (300 occurrences) and /ḍa/ syllable with a frequency of occurrence of 20% (60 occurrences). The sequence was presented binaurally to each participant at a comfortable loudness level (i.e., the intensity was set at 70% in the auditory evoked potential system which was equivalent to 65 dB SPL) using headset with TDH 39 headphones connected to the laptop with compatible AEP software. Figure 1 depicts the waveforms and spectrograms of the /ba/ and /ḍa/ syllables used for the P300.

It must be noted here that the stimulus had 100 ms. of silence duration before the onset of syllable for the purpose of baseline correction.

Table 1: Stimulus and acquisition parameters set to record P300

P300-Stimulus Parameters	
Stimulus	/ba/- frequent (80% i.e., 300) /ḍa/- infrequent (20% i.e., 60) } Odd ball
Intensity	70% (equivalent to 65 dB SPL)
Stimulation rate (in Hz)	0.3
Transducer	TDH 39 Headphones
Presentation	Binaural
P300-Recording Parameters	
Filter Setting	0.1-30 Hz
Artifact rejection	+/- 150 µV
Analysis time	1000 ms.
Notch filter (type)	On (Adaptive)
Electrode Montage	Vertical (2-channel) Positive - P3, P4 Negative - Linked to tip of nose Ground - Nasion

Procedure

The air-conduction and bone-conduction hearing thresholds were established for each participant, at octave frequencies from 250 Hz to 4000 Hz for all test ears, using modified Hughson-Westlake procedure. [31] Further, the P300 was recorded using the two-channel auditory evoked potential system. The stimulus and acquisition parameters used to record P300 are given in the Table 1.

The participants were made to sit comfortably on a chair in a sound treated room. Prior to the data collection, informed consent was obtained from each participant. Following this, the participant was prepared for the testing. As mentioned in above Table 1, four electrode sites were employed to record P300. They were parietal position on left hemisphere (P3), parietal position on right hemisphere (P4), tip of the nose and Nasion based on International 10/20 system as shown in Figure 2. [32] All the four electrode sites were cleaned using the cleaning gel, and gold plated disc electrodes were placed using 10-20 conduction paste. At this point, the impedance was ensured to be less than 5 kΩ. If the impedance was higher, the cleaning procedure was repeated. The parameters required to record P300 were set appropriately in the software before recording the ERP. Following this, the participants were instructed suitably before presenting the stimuli. The participants were given practice trials, if required.

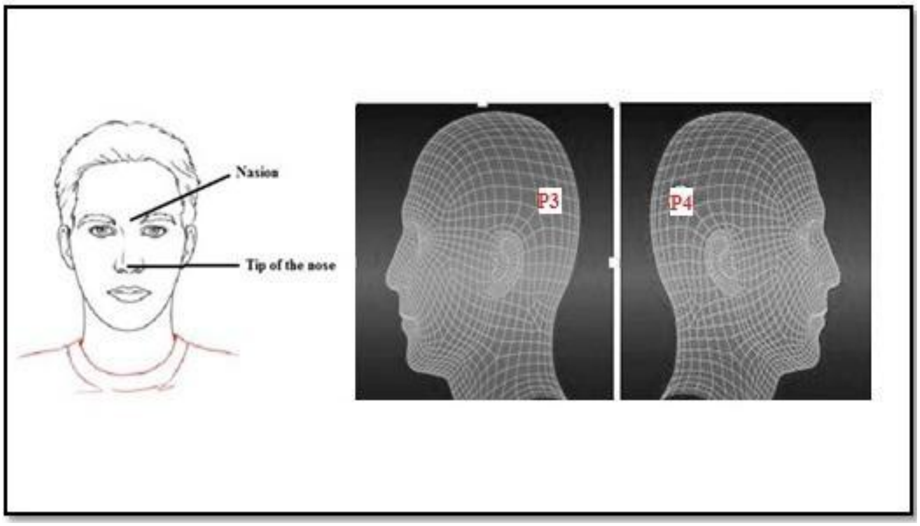


Figure 2: Electrode sites for P300 recording.

Instruction to the participants for P300

"I will place these headphones on your ears. You will be hearing speech sounds in a sequence. For example, ba, ba, ba, da, ba, ba …. You have to listen carefully to these speech sounds and whenever you hear the /ba/ sound you have to press "1"; and whenever you hear /ḍa/ sound, you have to press "2". We will start when you are ready. You need to continue to do this till you stop hearing the sound. The procedure may take about 15 minutes"

Once the sweep was presented completely, the morphology of the recorded waveform was inspected. If the morphology was clear, the waveforms were stored for further analysis.

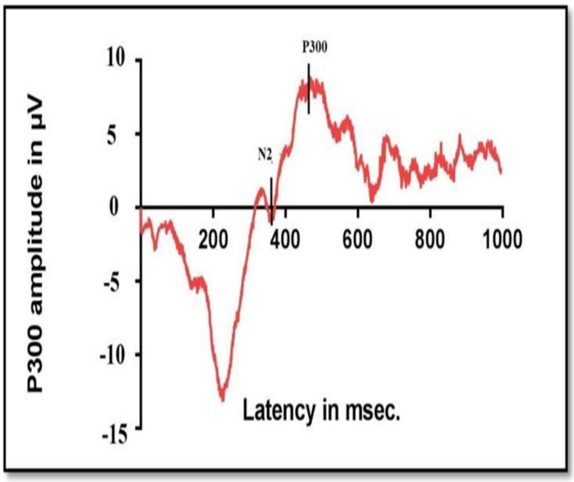


Figure 3: Marking on grand average P300 waveform of 30-40 years age group (Note: Latency delay is due to the presence of 100 ms. of silence duration before the onset of syllable).

Analysis of P300

The P300 waveforms were inspected visually to check if the waves were clear in morphology, distinct and not hazy. The data points of individual waveforms were exported to MS Excel Chart and tabulated as per the objectives of the study. The grand average data points for each age group were computed using data points of each test ear of individual participant. Further, grand average waveforms for different age groups were plotted using the averaged data points of each age group. Three qualified and experienced audiologists served as judges in order to identify the peaks in the grand average waveform. Individual waveform analysis of each participant was carried out based on the peaks marked in the grand average waveform. The following measures were extracted from each waveform of each participant for analysis:

1. Latency: The latency of the P300 peak was measured from the time of onset of stimulus (in ms.) to the appearance of the peak as displayed on the time window (Polich, 2007).

2. Amplitude: The peak-to-peak (N2-P3) amplitude, in microvolt (µV), was computed.

An example of the procedure followed is shown in Figure 3.

RESULTS

The intended measures were analyzed from the data collected and tabulated across gender, age and type of stimuli in the experiments as per the objectives of the study. This was subjected to statistical analysis. Shapiro-Wilk test for normality was administered initially to check if the data met the normality assumption. Since, there was violation of normality assumption ($p < 0.05$) for stimuli, age and gender; non-parametric tests were used to analyze the effect of stimuli, age and gender. The outliers in the data were not significant and hence they were not removed from the data.

The results are presented under following sub-headings:

1. Comparison of P300 across gender
2. Comparison of P300 across age groups

1. Comparison of P300 across gender

For ease of analysis, initially, the latency and amplitude of P300 were compared between two sites P3 (left parietal) and P4 (right parietal). Wilcoxon Signed Rank test was run to check for the difference between P3 and P4 channels as a factor of age and irrespective of age. There was no significant difference in P300 latency ($Z= -.234$, $p = 0.815$) and amplitude ($Z= -1.19$, $p = 0.233$) between the two recording sites (P3 & P4) when age was not considered as a factor. Similar findings were seen for comparison between the two sites in each age group ($p >0.05$ for both latency and amplitude). Therefore, in further statistical analysis, latency and amplitude of P3 site was considered since the amplitude was larger and latencies were earlier at P3 site compared to P4 site. The mean, median and standard deviation of latency and amplitude of P300 at P3 site for each age group and gender are depicted in Table 2.

Table 2: Mean, median and standard deviation of latency (in ms.) and amplitude (in µV) of P300 for /ḍa/ across age and gender.

P300 measures		Female					Male				
		Age groups (in years)									
		20-30 (N=11)	30-40 (N=12)	50-60 (N=8)	60-70 (N=3)	Overall (N=34)	20-30 (N=9)	30-40 (N=8)	50-60 (N=8)	60-70 (N=5)	Overall (N=30)
Latency of P300 for /ḍa/ (in ms.)	Mean	459.78	471.89	457.71	531.37	469.89	457.14	463.68	499.74	518.84	480.53
	Median	443.20	476.90	454.40	564.90	463.65	461.70	474.90	498.75	513.30	480.85
	SD	46.84	46.76	45.62	63.88	49.98	31.66	42.54	45.10	45.34	45.73
Ampli-tude of P300 for /ḍa/ (in µV)	Mean	10.65	8.67	5.64	10.03	8.71	10.81	8.62	5.32	6.28	8.01
	Median	9.90	7.30	5.45	13.30	7.40	9.70	8.90	4.80	4.80	7.20
	SD	4.47	5.64	2.90	6.00	4.93	5.37	4.42	3.00	2.59	4.56

Further, Mann-Whitney U test was carried out to check for significant difference across gender under all age groups and the same is shown in Table 3. There was no significant difference (p >0.05) observed between the data of male and female participants in different age groups.

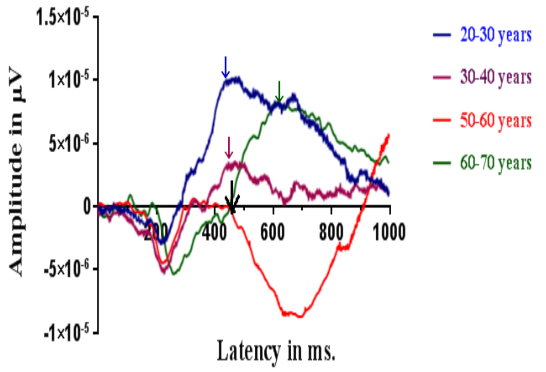
Table 3: Comparison of Latency and Amplitude measures of P300 across gender in different age groups using Mann Whitney U test.

	P300 latency at P3 site					P300 amplitude at P3 site			
	Age groups (in years)								
	20-30	30-40	50-60	60-70		20-30	30-40	50-60	60-70
Z	-0.34	-0.23	-1.5	-0.70		-0.38	-0.38	-0.42	-0.70
p	0.73	0.81	0.12	0.48		0.97	0.70	0.67	0.48

As seen from Table 3, the difference between P300 measures in male and female participants across individual age groups was not statistically significant. Therefore, the data were combined irrespective of gender and subjected to Mann-Whitney U Test which indicated no significant gender difference for P300 latency at P3 site (Z= -1.014, p = 0.311) and P300 amplitude at P3 site (Z= -.297, p = 0.767).

2. Comparison of P300 across Age.

As mentioned in the earlier, P300 waveforms were averaged using data points in MS Excel for each age group. The grand average waveforms for different age groups are depicted in Figure 4. The mean, median and standard deviation of P300 latency and amplitude for different age groups are represented in Table 4. The P300 peak in six participants was not identifiable due to poor waveform morphology (three participants in 50-60 year age group and three participants in 60-70 age group). Therefore, P300 data for the remaining 64 participants were subjected to statistical analyses to know the effect of age on P300 measures. The box plots in Figures 5 and 6 depict P300 latency and P300 amplitude across different age groups.



(Note: The downward pointing arrow indicates P300 peak)

Figure 4. Grand average waveforms of P300 for /ḍa/ syllables from P3 site across age groups.

Table 4: Mean, median and standard deviation of latency (in ms.) and amplitude (in µV) of P300 for /ḍa/ across different age groups.

P300 Measures		Age groups (in years)				
		20-30 (N=20)	30-40 (N=20)	50-60 (N=17)	60-70 (N=7)	Overall (N=64)
P300 latency (in ms.)	Mean	458.60	468.60	478.72	523.54	474.87
	Median	451.10	476.90	482.20	529.1	470.30
	SD	39.73	44.16	48.90	48.81	47.96
P300 amplitude (in µV)	Mean	10.72	8.65	5.48	7.68	8.38
	Median	9.80	8.35	5.20	6.40	7.25
	SD	4.76	5.06	2.85	4.23	4.74

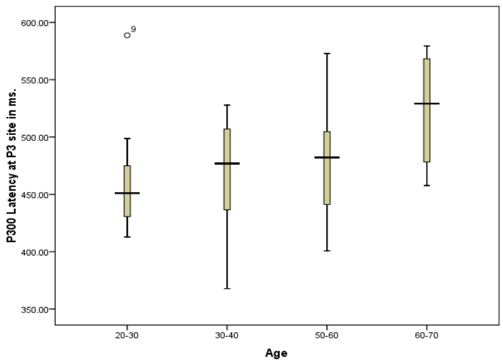


Figure 5. **Mean P300 latency (in ms.) across different age groups for /ḍa/ (infrequent) syllable.**

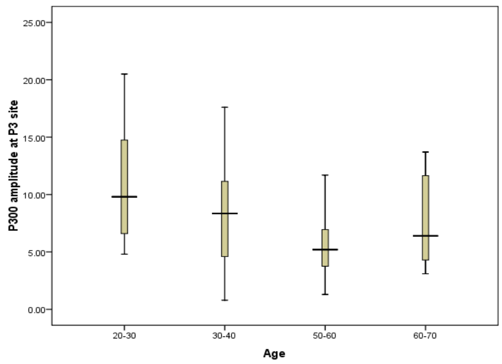


Figure 6. **Mean P300 amplitude (in µV) across different age groups for /ḍa/ (infrequent) syllable.**

It was also observed that the latency increased significantly with increase in age, whereas, the amplitude reduced significantly with increase in age. Kruskal Wallis test was used to check for any significant difference in P300 latency and amplitude across different age groups. There was a significant difference for both P300 latency ($\chi2$ (3) =7.673, p = 0.053) and P300 amplitude ($\chi2$ (3) = 11.606, p = 0.009) between different age groups. Further, Mann-Whitney U Test was performed to make pair-wise comparison of age groups for latency and amplitude measures of P300. The results of the Mann-Whitney U test are shown in Table 5.

Table 5: Pair wise comparison of age groups and the significant differences in P300 latency and amplitude measures on Mann-Whitney U Test

Age groups (in years) - comparison		P300 measures	
		Latency (in ms.)	Amplitude (in µV)
20-30 and 30-40	Z	-1.326	-1.393
	p	0.192	0.165
20-30 and 50-60	Z	-1.449	-3.488
	p	0.147	0.000*
20-30 and 60-70	Z	-2.603	-1.163
	p	0.009*	0.245
30-40 and 50-60	Z	-.302	-1.942
	p	0.765	0.053*
30-40 and 60-70	Z	-1.936	-0.111
	p	0.053*	0.912
50-60 and 60-70	Z	-1.370	-1.238
	p	0.171	0.216

Note: *significant at $p < 0.05$

The difference in P300 amplitude and latency was not significant when compared between 20-30 and 30-40 age group and 50-60 and 60-70 age groups. The P300 amplitude in 50-60 age group was significantly lesser than 20-30 or 30-40 age groups. Further, there was a significant difference seen in P300 latency between 20-30 and 60-70; and 30-40 and 60-70 age groups. The P300 latency was significantly prolonged in 60-70 age group compared to 20-30 or 30-40 age groups.

DISCUSSION

The results of this study are discussed under following heads.

1) Comparison of P300 across Gender.

P300 in the present study was recorded from two parietal sites (left hemisphere and right hemisphere), considering that larger amplitude is obtained for parietal electrodes compared to other sites. [33] Before carrying out analysis to check for gender effect; the P300 measures, latency and amplitude, from both the sites were compared. The results of Wilcoxon Signed Rank test revealed no significant difference across the two sites irrespective of age, though the mean latency was better and amplitude was larger at left parietal site (P3) compared to the parietal site at right hemisphere (P4). This is in consonance with findings in existing literature of maximum P300 amplitude for Pz site followed by left hemisphere parietal region (P3) than Cz, Fz, and P4 sites. [34] Therefore, P300 results from parietal site of left hemisphere were considered for further analysis.

In the present study, the /ḍa/ syllable which occurred infrequently, recorded a signal frequency as low as 20% so as to obtain P300 with larger amplitude. This is in agreement with other existing findings. [10] On examining the grand averages of P300 waveforms for all the age groups, it was found that P300 latency was delayed and was around 450 ms. as reported in Table 15. However, occurrence of P300 is reported at latency of 300 ms. [9] It may be noted that in this study, the /ḍa/ and /ba/ stimuli had initial silence duration to the extent of 100 ms. as represented in Figure1; since, the latency is measured from the onset of the stimulus there was an increase in latency by 100 ms.

Comparison across gender and age for P300 latency and amplitude for overall data revealed no significant difference across gender. Similar findings are also documented in literature. [35] Hence the data were from male and female participants grouped together for further analyses. It has been reported that P300 varies with the type of task and probability percentage of rare occurring stimuli. [35] The type of task and probability percentage of rare occurring stimuli was kept constant across gender. Hence, it can be construed that there was no difference in cognitive abilities across males and females based on P300 event related potential. However, on observing the mean values, it was noticed that P300 latencies were shorter and P300 amplitude was higher for females than males. It was also seen that variability, as depicted by standard deviation values, was higher in females compared to males.

2) Comparison of P300 across Age.

There was an increase in P300 latency with age. It may be noted that for three participants in 50-60 year age group and three more in 60-70 age group, a reliable recording of P300 was not obtained. This is in consonance with literature where presence of P300 is reported only in 52% of the subjects above 60 years of age. [20] In this study too, the occurrence of P300 was seen to decrease as age increased. Higher standard deviations for P300 latency was seen in 50-60 and 60-70 age groups compared to the lower age groups, i.e., 20-30 and 30-40 age groups. There was a reduction in amplitude of P300 from 20-30, 30-40 to 50-60 age group. But, there was a sudden increase in amplitude in 60-70 age group. It has been documented in literature also that ageing process is very well reflected in auditory evoked potential results. [14,16,17,18]

The results of the inferential statistics indicated that there was a significant difference in P300 latency and P300 amplitude across age. The trend was such that, P300 amplitude reduced significantly and P300 latency increased with increase in age. This finding suggests that cognitive decline is well reflected in P300 findings. When pair-wise comparisons were made among age groups, it was seen that 20-30 and 30-40 age groups did not vary significantly in terms of P300 latency and amplitude. On a similar note, there was no significant difference between 50-60 and 60-70 age groups in terms of P300 latency and amplitude. There was a significant reduction in amplitude in 50-60 age groups compared to 20-30 and 30-40 age groups. Further, it was seen that 60-70 age group showed significantly longer latency than the 20-30 or 30-40 age groups. This finding can be attributed to ageing effect causing slower conduction velocity, resulting in significant reduction of amplitude and significant increase in latency. Systematic increase in latency and reduction in amplitude with age has also been reported in literature. [13]

There was increase in P300 latency in 60-70 age group compared to other age groups but amplitude was more compared to 50-60 years age group. Since, there were less number of participants in 60-70 years age group, it is difficult to generalize the finding. Similar effect of ageing on CAEP with increase in N1- P2 amplitude and P2 latency are widely reported. [14,16,17] It is also reported that elderly adults (range 62-77 years) had higher N1 and P2 amplitude than younger adults (range 19-29 years) for auditory oddball paradigm in quiet condition which was attributed to adults deploying compensatory mechanisms while listening in quiet. [18]

The amount of increase in P300 latency was quantified from 18 to 90 years of age and an increase of 1-1.5 ms/year was reported. [15] In the present study, there was increase in P300 latency by 64.94 ms. from 20-30 to 60-70 years age group. This corresponded to 1.62 ms/year increase in P300 latency which is in consonance with the other study. [15] Whereas, there was increase in latency by 10 ms. from 20-30 and 30-40 years which computes to an increase of 1ms./year. There was an increase of 10.12 ms. from 30-40 to 50-60 years thereby resulting in rate of increase of P300 latency by 0.5 ms./year. Lastly, from 50-60 to 60-70 years, increase in latency of P300 was by 4.48 ms./year. Therefore, the rate of increase of P300 latency with age is not linear or constant across years and varies greatly, specially higher rate of increase is seen in higher age groups. Moreover, there was no significant difference in P300 latency and amplitude across 20-30 and 30-40 age groups but significant difference existed above this age group. Hence, it can be speculated that ageing process begins after 40 years of age. P300 seems to be an efficient tool in assessing cognitive decline with advancing age. It could probably help in determining the age of onset of ageing process, which needs to be ascertained through more evidence.

CONCLUSION

In the present study, the ageing effect was clearly depicted through P300 measures. Hence, to study cognitive decline due to ageing, P300 measure can be used in future studies. The tasks and the protocols used in this study can also be used with persons with various communication disorders where cognitive linguistic functions are declining/have declined. In this study, syllables were used for P300 task. Syllables being language insensitive, it can be used with participants with any linguistic background.

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