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Original Article

Effect of Age and Gender on Cognitive Function as Assessed by p300 Potentials

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ABSTRACT

Background: Higher mental functions decline as age advances, sometimes leading to overt dementia which compromises an individual's day-to-day activities. Contrary to this, some elderly individuals show remarkable intellectual capabilities, which drive our attention to the factors apart from age that are detrimental to cognitive functions. Gender is an important factor that needs to be considered while assessing cognitive functions. Aims and objectives: The aim of the present study was to interpret the pattern of cognitive decline with respect to age and to compare the difference in cognitive potentials among males and females. Materials and methods: The study was conducted on 61 apparently healthy subjects. Subjects were divided into 5 sub-groups based on age(Group I: 16-25 years, Group II: 26-35 years, Group III: 36-45 years, Group IV: 46-55 years and Group V: 56-65 years). The p300 cognitive potentials were recorded using Nicolet Viking Select (Viasys Healthcare, U.S.A.). Results:The p300 latencies exhibited increasing trend and p300 amplitudes showed decreasing trends in the consecutive age groups. However, the change between the consecutive age groups was statistically not significant. Also, in the corresponding age groups, there was no significant difference between males and females. Conclusions: The increasing trend in the p300 latencies indicate subtle decline in cognitive functions though these changes were not statistically significant. We also conclude that there is no gender disparity in the cognitive performance in the same age group.

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1. Introduction

Age-related cognitive functions differ significantly across individuals as well as across cognitive realms, with some cognitive functions appearing more susceptible to the effects of aging than others [1]. Cognitive functions change with age and these changes are variable. In spite of cognitive decline being inexorable, some elderly people retain their cognitive abilities beyond 70 years of age and perform better than younger individuals [2]. Variations in inter-individual cognitive functioning can be attributed to various biological, environmental and psychological factors [3]. As the child grows the number of neurons does not increase much, instead the existing neurons make extensive connections with one another depending on the external environment which facilitates learning, memory, acquisition of new skills, rational behavior, judgment, etc. As the individual approaches senility, the nervous system function declinesnot due to decrease in the number of neurons but due to the intracellular changes occurring in the remaining neurons. Reaction time may decline with age while knowledge and wisdom may expand. Further research on this decline may be beneficial as mild forms of cognitive impairment might hamper day-to-day activities depending on work and situation, which require various cognitive domains such as general intelligence, processing speed, psychomotor efficiency, attention, perception, learning, memory and executive functions[4]. This study attempts to evaluate the effect of age on cognitive abilities of an individual.

Peters et al[5] conducted a study on rhesus monkeys and concluded that age-related cognitive changes in them began at the age of 20 years. Some parameters in the brain did not change with age like the number of neurons in the neocortex and hippocampal

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formation; and the number of synapses in the hippocampus. However, increase in the number of neuritic plaques, decrease in number of substantianigra neurons and decreased thickness of layer 1 of visual cortex were observed with increase in age. It was suggested that the neurological basis of cognitive decline a so bserved in rhesus monkeys was due to changes in the layer 1 of visual cortex and loss of myelination around axons and not due to decrease in the number of cortical neurons or synapses. Sze et al [6] found out in their study that loss of synaptophysin, a presynaptic vesicle protein present in hippocampus, correlates with decline in cognitive abilities in early Alzheimer's disease. Näslund et al [7] found out in their study that elevated levels of amyloid beta peptide in the brain relate positively with cognitive decline in the elderly.

In addition, some studies have also shown that males and females differ in the use of their cognitive abilities while processing information [8]. This study also aims to compare the gender-specific differences in mental alertness or cognitive abilities and to evaluate the rate of decline separately in males and females.

The p300 event related potential (ERP) can predict the rate of cognitive deterioration as it measures the speed of neural events related to attention and short term memory much before the onset of various subjective symptoms related to memory impairment. Change in p300 waveform is often co-related with cognitive decline and therefore can be used as a diagnostic and prognostic marker of memory decline.

2. Materials and methods

This study was conducted in the Electrophysiology laboratory, Department of Physiology after getting approval from Institutional Ethics Committee and informed consent from all subjects. The study was conducted on 61 healthy subjects (31 males and 30 females) in the age group of 15-65 years over a period of one and a half month. The subjects were divided into 5 sub-groups based on their age (Group I: 16-25 years, Group II: 26-35 years, Group III: 36-45 years, Group IV: 46-55 years and Group V: 56-65 years). Demographic data of subjects were obtained. The p300 cognitive potentials were recorded in each subject using Nicolet Viking Select neuro-diagnostic system version 10.0. Subjects with a history of diabetes mellitus, hypertension, asthma, thyroid disorders or any other chronic diseases were excluded.

Recording of p300 potential

Nicolet Viking Select (Viasys Healthcare, U.S.A.) was used to elicit p300 cognitive potential. The recording was done in a silent room with subjects in reclining position and eyes closed in order to eliminate artifacts caused by movements. Two channel recording with active electrodes connected to bilateral mastoids (A1/A2) and reference electrodes connected to the scalp at Cz and Pz position was done. Ground electrode was connected to the Fpz position and impedance was kept below 5 kilo-ohms. Stimuli were delivered using TDH-39P headphones at a frequency of 1.0 Hz. A two-stimulus odd-ball paradigm characterized by random presentation of a rare stimulus interposed in presentation of frequent stimulus was designed. The characteristics of the stimuli are depicted in Table 1. Subjects were asked to recognize and keep a mental count of the rare stimulus and not respond to the frequent stimulus.

The test was run for 2 sets to confirm reproducibility of signals. The responses were averaged over 200 sweeps in each set, in such a way that at least 40 artifact free event related potentials (ERPs) were obtained, which is sufficient to stabilize p300 latency and amplitude. Statistical analysis was performed using PASW 18.0 (SPSS Inc., Chicago, USA). One-way analysis of variance (ANOVA) or Welch/Brown-Forsythe test was done depending on the significance of Levene's test of homogeneity of variances. Tukey's HSD (Equal variances assumed) and Tamhane's (Equal variances not assumed) Post-Hoc tests were performed for statistical significance. The statistical significance was set at $p< 0.05$.

3. Results

Table 2 shows the number of subjects in each age group. The variation in p300 latencies and amplitudes in various age groups is given in Table 3 and between males and females in Table 4. Figure 1 and 2 showed increasing trends in p300 latencies and decreasing trends in p300 amplitudes respectively in both genders in consecutive age groups. The actual change between the consecutive groups in males with respect to p300 latency at Cz (group I vs group II: $p = 0.924$; group II vs group III: $p = 0.145$; group III vs group IV: $p = 0.399$ and group IV vs group V: $p = 0.998$) and with respect to p300 latency at Pz (group I vs group II: $p = 1.000$; group II vs group III: $p = 0.780$; group III vs group IV: $p = 0.201$ and group IV vs group V: $p = 1.000$) was not statistically significant. Likewise, differences in p300 amplitudes at Cz and P zin different age groups is not statistically significant in males. Similar trends were seen in female subjects, with the exception of group II vs group III which showed statistical significance with respect to p300 latency at Cz ($p = 0.004$), p300 latency at Pz ($p = 0.012$), p300 amplitude at Cz ($p = 0.021$) and p300 amplitude at Pz ($p = 0.017$).

The differences in p300 latencies and amplitudes between males and females in corresponding age groups were not statistically significant.

Table 1: Stimulus characteristics

Stimulus	Probability	Type	Ear	Character	Polarity	Intensity	Frequency
Frequent	80 %	Auditory	Both	Click	Rarefaction	70 dB	750 Hz
Rare	20 %	Auditory	Both	Pip	Rarefaction	94 dB	2.0 kHz

Table 2: Number of subjects in each group

Group	Age (in years)	No. of subjects
I	16-25	22
II	26-35	8
III	36-45	8
IV	46-55	15
V	56-65	8

Table 3: p300 latencies and amplitudes in various age groups

Group	p300 latency at Cz (ms)	p300 latency at Pz (ms)	p300 amplitude at Cz (µv)	p300 amplitude at Pz (µv)
I	306±21	307±28	21.25±5.61	19.36±6.27
II	298±23	298±22	18.09±5.74	19.43±3.54
III	346±34	335±33	6.14±5.12	5.77±3.80
IV	362±21	357±24	7.22±5.63	7.53±6.36
V	359±18	358±17	6.32±3.78	6.13±5.61

Numbers represent mean ± standard deviation at 95% confidence interval

Table 4: The p300 latencies and amplitudes between males and females

Group	p300 latency at Cz (ms)		p300 latency at Pz (ms)		p300 amplitude at Cz (µv)		p300 amplitude at Pz (µv)	
	Male	Female	Male	Female	Male	Female	Male	Female
I	307±16	305±25	297±23	316±30	19.10±4.27	23.40±6.14	17.56±4.68	21.16±7.32
II	296±36	299±18	300±30	297±19	18.57±6.35	17.80±6.10	20.27±2.86	18.92±4.12
III	333±32	368±29	320±30	362±19	6.87±6.48	4.93±2.04	6.98±4.25	3.74±2.13
IV	355±16	366±24	351±26	361±23	9.50±6.62	5.70±4.64	8.88±6.85	6.63±6.26
V	351±11	384±13	350±6	383±18	6.56±4.41	5.61±1.13	6.54±6.57	4.90±0.74

Numbers represent mean ± standard deviation at 95% confidence interval

Figure 1: Variation in mean p300 latency at Cz (a) and Pz (b) with respect to age and gender

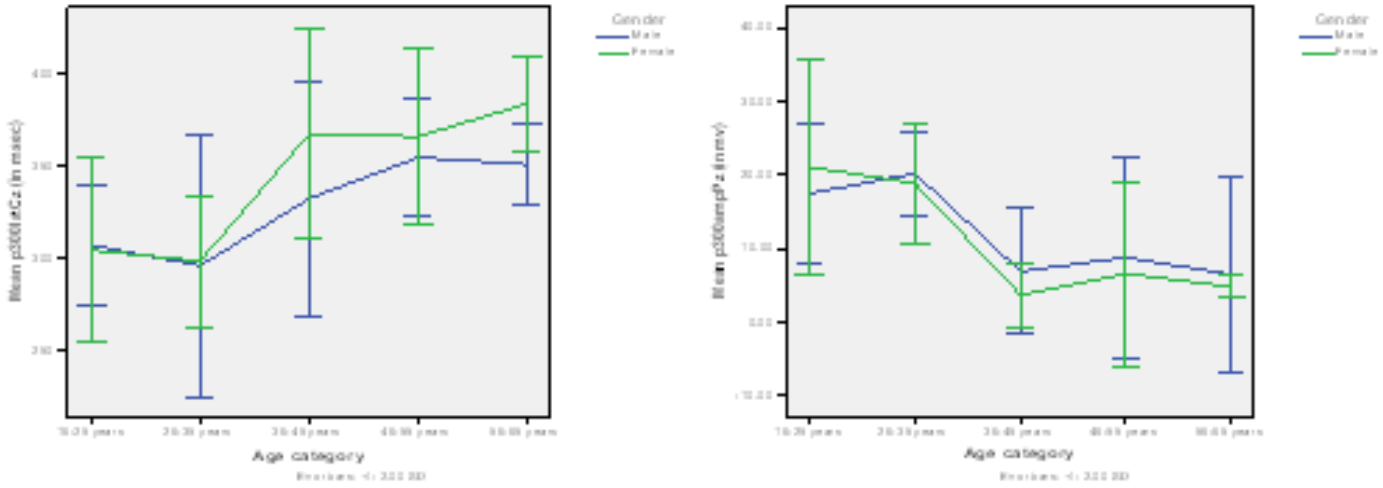
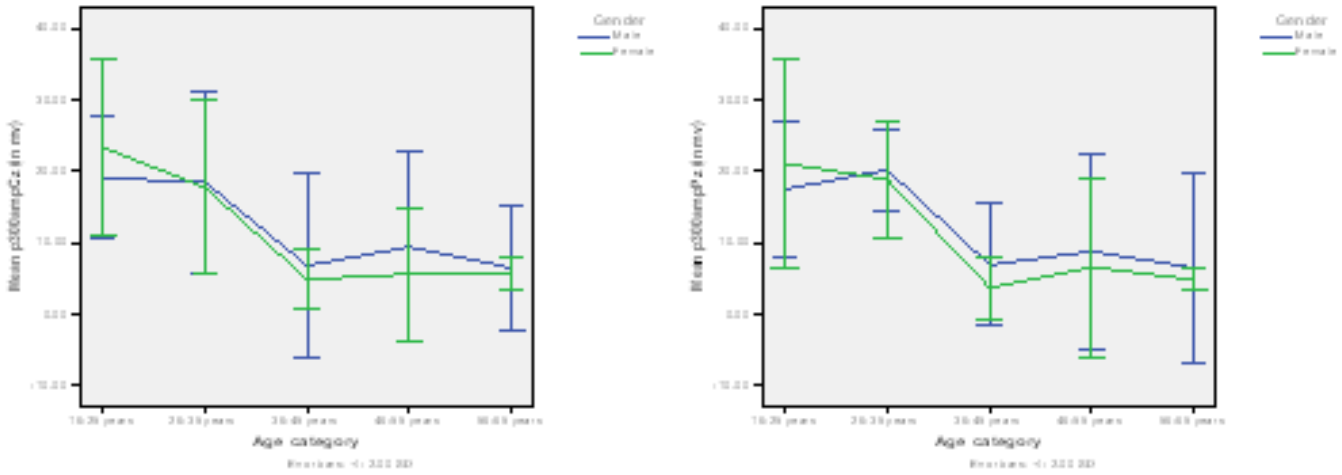


Figure 2: Variation in mean p300 amplitude at Cz (a) and Pz (b) with respect to age and gender



4. Discussion

The present study involved two-stimulus odd-ball paradigm with the rare stimulus as the target. This study showed anincreasing trend in the latent periods of p300 cognitive potentials in both genders as age advances, & but did not follow a linear pattern. There was only a slight increase in the latencies in younger age groups but much more increase in middle and elderly age groups. However, the differences in the latencies between the consecutive groups were statistically not significant which is in disagreement with previous studies which concluded that there is a significant decline in cognitive abilities with age [9]. The amplitudes of p300 reflect the amount of neural mass involved in signal processing [4]. In our study p300 amplitudes showed a decreasing trend in both genders as the age advances but was not significant statistically, and hence we assume that there is no change in number of neurons involved in memory circuitry.

It has been suggested that age related cognitive decline is due in part not to the neuronal death, but in fact, synaptic alterations. Studies suggest that the age related cognitive deficit is due to functional and biochemical changes such as enzymatic activity, chemical messengers, or gene expression in cortical circuits [4,5]. It may also be related to age-induced atherosclerotic changes in the cerebral vasculature [10]. Since p300 has high temporal resolution than spatial resolution, it corresponded more to latencies than amplitudes in our study.

In this study, we did not find any differences in cognitive abilities as assessed by p300 between male and female gender of same age group which is in disagreement with the findings of Guillem and Mograss [8].

Limitations of the study: The sample size is small and unequal in different age groups.

5. Conclusion

There is a non-linear subtle cognitive decline with advancing age as assessed by p300 latencies. Also, there is no gender difference in cognitive performance in the same age group.

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Conflict of interest: The authors declare no conflict of interest.

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