ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

A Comparative Study of Visual Event Related Potential (P300 Wave Amplitude and Latency) With Novel and Repeat Stimulus in Young Healthy Adult Males.

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ABSTRACT

Event Related Potential (ERP) is a time locked measure of electrical activity of the cerebral surface representing a distinct phase of cortical processing. The P300 wave is a centro parietal positivity that occurs when a subject detects an informative task relevant stimulus. The latency and amplitude of P300 can be used as an index for the assessment of neural processing time and the neural cognitive activity. 32 Right handed healthy males (18-23years) with normal visual acuity were randomly selected for the study. Visual ERP recording was done using odd ball paradigm on Brain Electro Scan System, version 4.0. Each stimulus was presented for 2 seconds followed by next stimulus with 2 seconds inter stimulus interval. They were asked to count the novel stimuli whenever it appears on the screen. EEG electrodes were positioned on scalp as per the International 10-20 system. Centro Parietal sensors Cz & Pz electrodes were used as active recording electrodes. Mean P300 wave amplitude and latency was calculated. P300 wave amplitude and latency is found to be significantly higher ($P \leq 0.001$) with novel stimulus as compared to repeat stimulus in the study. Hence it is concluded that novelty influences the P300 wave amplitude and latency.

Keywords – Event Related Potential, P 300 wave, Cognition, Odd ball Paradigm.

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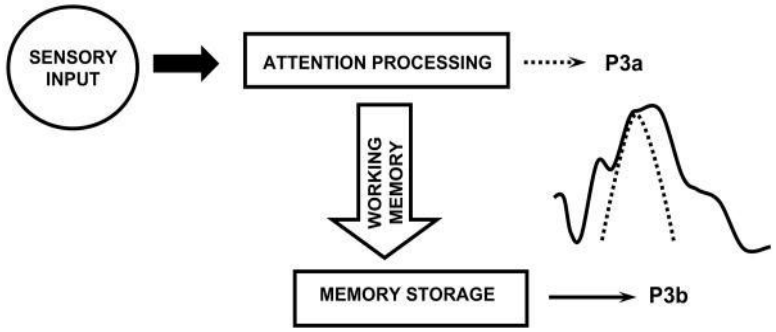
ISSN: 0975-8585

INTRODUCTION

The Event-Related Potential (ERP) is a time-locked measure of electrical activity of the cerebral surface representing a distinct phase of cortical processing [1]. ERPs provides online information about neuro physiological processes related to a range of cognitive tasks [2]. ERPs exhibit excellent time resolution, they reflect the processing of information millisecond by millisecond [3].

The P300 wave is a centro parietal positivity that occurs when a subject detects an informative task relevant stimulus. The P300 name derives from the fact that its peak latency is about 300ms when a young adult subject makes a simple sensory discrimination [4]. It has also been called the P3 Wave because it is the third major Positive peak in the late sensory evoked potential and Late positive component(LPC) [5].

Classically, the P300 response is divided into 2 sub components: P3a and P3b. The P3a component is mainly distributed in frontal regions and its usual latency ranges from 220 to 280milliseconds [2]. P3a amplitude exhibits rapid habituation which depends on novelty of stimuli. P3a reflects automatic cognitive processing and the orientation response. This Novelty P300 is sometimes called the P3a. In contrast, the P3b component presents a centro parietal topography and a longer latency usually comprised between 280 – 600milliseconds [6]. In studies on ERPs, measurement of the P300 is generally centered on the P3b and elicited via an auditory or visual oddball paradigm (based on the detection of infrequent stimuli among a train of regular stimuli) [7].



P300 Wave Generation

In a very simple but widely used experimental task – the so called oddball paradigm – the participant is presented with two stimuli differing in some sensory characteristic (pitch of a tone, outlines of a geometrical shape, etc.). One of the stimuli (rare, target, significant) is presented relatively less frequently than the other (frequent, non-target, insignificant). A participant should make some response – either covert (such as silent counting) or overt (such as pressing a button) – to a rare target stimulus. The other stimulus does not require a response. In this case, non-target deviant stimuli that disrupt the ongoing oddball task generate both a large fronto - central P3a or Novelty P3 and a later parietal P3b [8].

S - Standard or Frequent stimulus
T – Target or Infrequent stimulus

ISSN: 0975-8585

Odd Ball Paradigm

Latency (ms) is typically defined as the time from stimulus onset to the point of maximum positive amplitude within this same time window [9]. P300 latency is thought to index classification speed, which is proportional to the time required to detect and process a target item [10].

P300 latency has been used as a metric for timing mental events producing other ERP components. P300 may originate from the neural events that link stimulus perception and event response [11]. Individual differences for P300 latency are correlated with mental speed, such that shorter latencies are related to superior cognitive performance.[12]

The neuropsychological tests that produce the strongest correlation between P300 latency and cognitive capability assess how rapidly subjects can allocate attentional resources.[13] P300 wave shows increase in amplitude and latency with novel target stimulus [14].

Aims and Objectives

To observe the Visual Event- Related- Potential with "Novel" and "Repeat" stimulus in young healthy adult males.

To compare the Visual Event- Related- Potential (P300 Amplitude and Latency) with "Novel" and "Repeat" stimulus in young healthy adult males.

MATERIAL AND METHODS

The study was conducted in the Upgraded Department of Physiology, S.M.S. Medical College, Jaipur. It was a Comparative type of observational study. The study was conducted from April 2013 to March 2014. Simple Random Sampling technique was used for selection of study population. Each and every eligible candidate fulfilling the inclusion criteria was included in the study. The study group comprised of 32 MBBS male students of age range 18–23 years studying in S.M.S. Medical College, Jaipur. Right handedness was assessed by using Handedness Questionnaire [15].

Inclusion Criteria

- Right handed young healthy adult males.
- Normal Visual Acuity.
- Cooperative for the procedure.

Exclusion Criteria

- Age <18yrs and > 23 yrs.
- Deranged visual acuity/ neurological / psychiatric disease.
- Subjects taking drug treatment for any purpose.

After explaining the procedure of the experiment, written informed consent was obtained from the subjects. Subjects were also instructed about the way of their response to the stimulus. A series of stimuli (number plates) were presented and each stimulus is to be viewed the entire time it is on the computer screen which was kept at 100cm. from the subject. They had to count the novel stimuli whenever it appears on the screen. After end of the study they had to tell the total number of times the novel target stimulus appeared on the screen.

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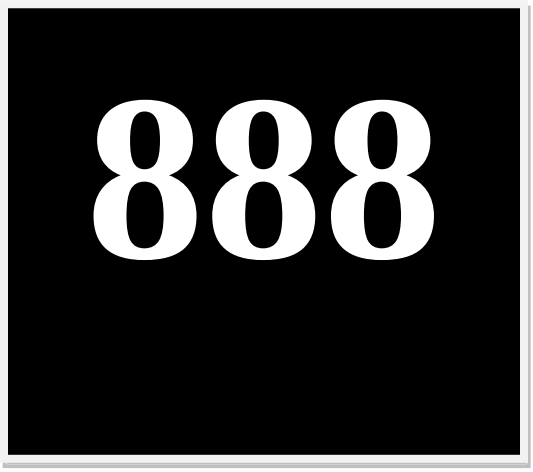
In the visual stimulus protocol using oddball paradigm 75% standard/ repeat stimulus and 25% novel/ target stimuli were presented in quick succession. Each stimulus was presented for 2s followed by next stimulus with 2s inter stimulus interval.

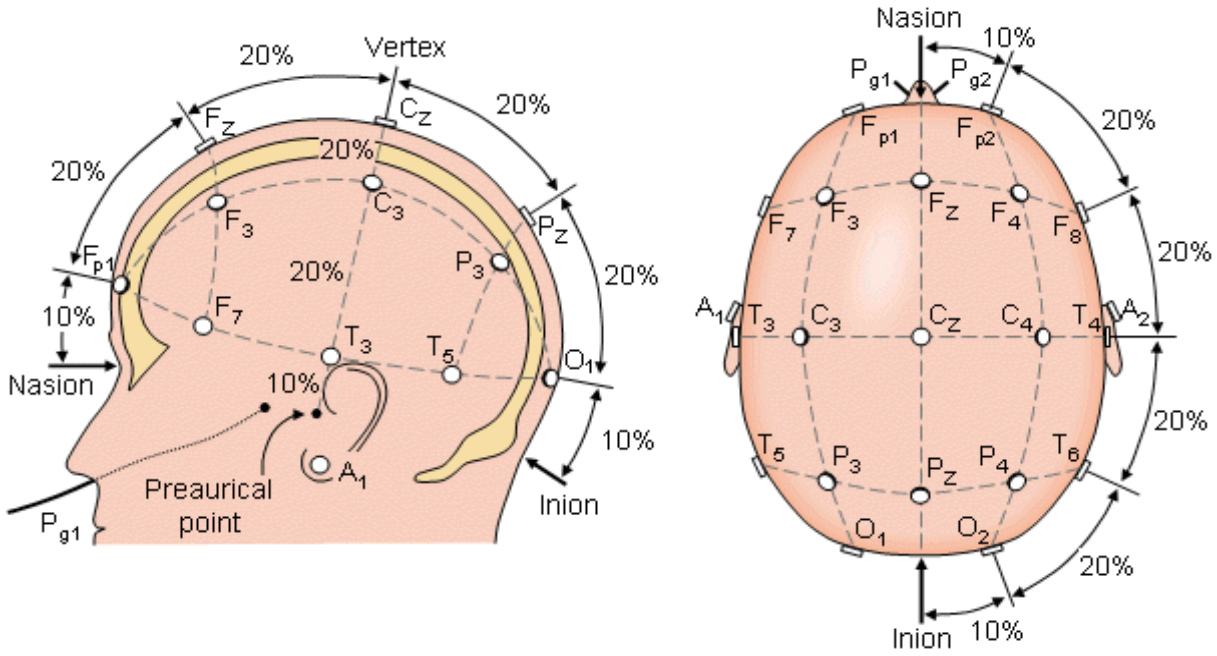


Standard Stimulus

Target Stimulus

The subjects were asked for shampooing of hairs, the night before the test and to avoid use of any hair cream, oils or spray thereafter. They were also asked to avoid all food and drinks containing caffeine for 2 hrs before the test.

Subjects were seated in a sound attenuated, dimly lit room. The 21 electrodes (Fpz,Fp1,Fp2,Fz,F3,F4,F7,F8,Cz,C3,C4,T3,T4,T5,T6,Pz,P3,P4,Oz,O1,O2) was positioned on the scalp according to the International 10-20 System of EEG Electrode Placement.[10]



International 10-20 System of EEG Electrode Placement

The vertex sensor was used as ground electrode and left ear lobe was used as reference electrode. ERP recording was done on Brain Electro Scan System, Version 4.0.[16] Impedance was kept below 5 Ω and electrical activities amplified with a band pass filter of 0.01-100 Hz.

The ERP recording was digitized at sampling rate 256 Hz. After completion of procedure, the data was analyzed offline & mean P300 wave amplitude and latency was calculated.

Paired 't' test was used to find out the significance of difference in P300 Wave amplitude and latency with "novel" & "repeat" stimulus in young healthy adult males using Microsoft excel software, 2010.

RESULTS AND CONCLUSION

P300 wave amplitude and latency at Pz & Cz Electrodes is found to be significantly higher ($P<0.001$) with novel stimulus as compared to repeat stimulus. Thus, it is concluded that novelty influences the P300 wave amplitude and latency.

DISCUSSION

In this study, we assessed the effects of stimulus novelty on the amplitude and latency of the P300 complex. In the classic oddball design, these two factors typically co vary because a rare stimulus tends to be both perceptually more novel as well as more significant to the ongoing task than the standard, repetitive stimulus. In fact, when pictures in the repeated condition (i.e. standard) were compared with those in the novel condition (oddball), a robust difference in P300 was obtained. P300 amplitude, however, was significantly modulated by both stimulus significance and perceptual novelty [17].

Over centro-parietal sensors, a larger P300 was found for stimuli that signalled a significant context change compared with those that did not signal a change. Thus, for both novel and repeated pictures, those that signalled a change in the structure of the current series elicited an enhanced P300 over centro-parietal sensors. These data are consistent with previous studies reporting increases in P3 amplitude as the information content of the cue increases. [18, 19, 20]

A recent interpretation of P300 (both P3a and P3b) is that it reflects "template updating"[21] in which attention allocation is heightened (hence, P3 amplitude) when a degraded template must be updated. Short-term memory presumably includes representations of recently presented stimuli. In this case, a template-updating (i.e. mismatch) hypothesis would predict a large P300 when a novel picture follows a repeated picture, which is quite consistent with the current data obtained in the study.

Latency is found to be prolonged when the stimulus needs more information processing and in cases of cognitive impairment. Faster the attention reorganization and the working memory update takes place, shorter is the P300 latency.[22]

Among the most prevalent chronic disorders of cognition in the elderly is Alzheimer's disease, typically affecting temporal and associative cortex regions; prolonged P300

Latency and attenuated amplitude have been observed in such patients.[23].

In our study, we compared the latency of P300 wave with novel and repeat stimulus. Prolonged latency was found with novel target stimulus as compared to repeat standard stimulus because the novel stimulus processing needs working memory updating and attentional reorganisation.

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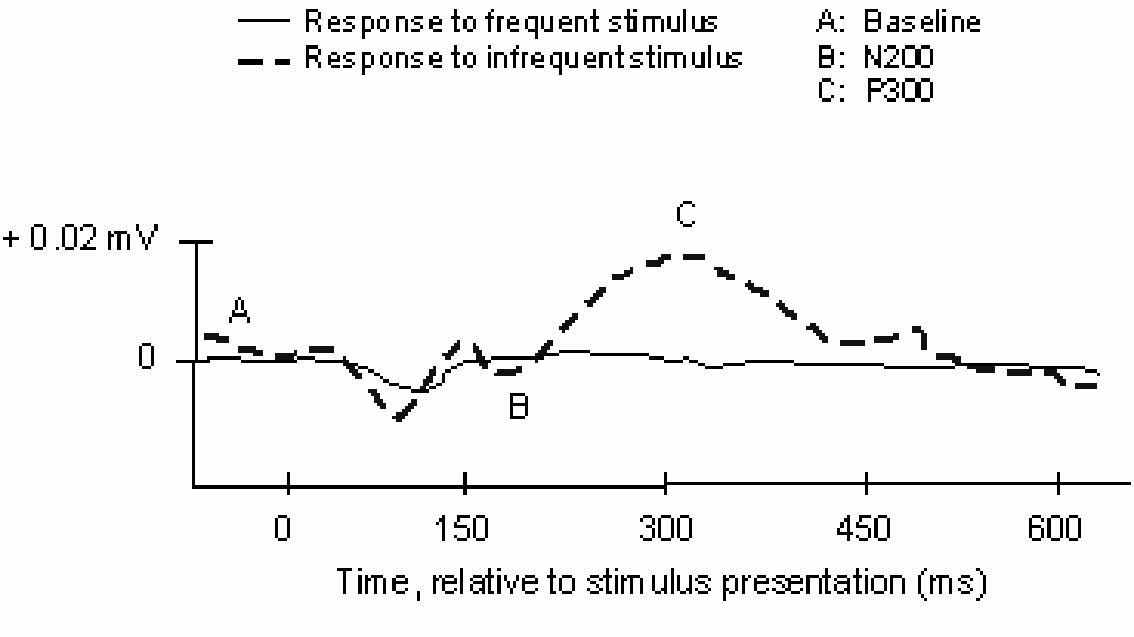
OBSERVATIONS



Electrode	*Parameters*	*Mean ± Standard Deviation*		*P - Value*	*Significance level*
		NOVEL	*REPEAT*		
Cz	Amplitude(µv)	2.41 ± 1.26	1.16 ± 0.76	≤ 0.001	HS
	Latency(ms)	437.15 ± 63.91	329.82 ± 65.57	≤ 0.001	HS
Pz	Amplitude(µv)	2.14 ± 1.21	1.11 ± 0.54	≤ 0.001	HS
	Latency(ms)	431.85 ± 60.89	347.74 ± 67.92	≤ 0.001	HS

Table – 1: Mean P300 wave Amplitude and Latency in Visual odd ball paradigm task at Cz and Pz electrode sites.

HS – Highly Significant.

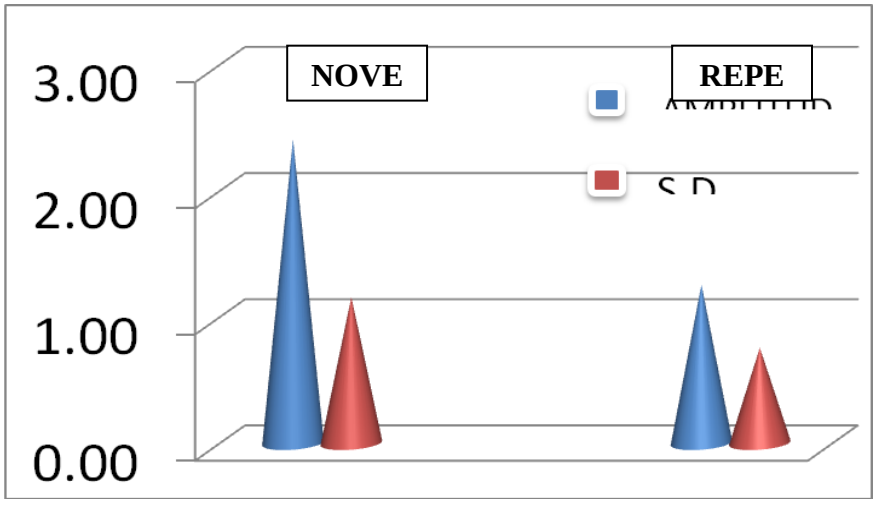


Figure 1:Representing the mean P300 wave amplitude at Cz electrode site is significantly higher (P ≤ 0.001) with novel as compared to repeat stimulus.

ISSN: 0975-8585

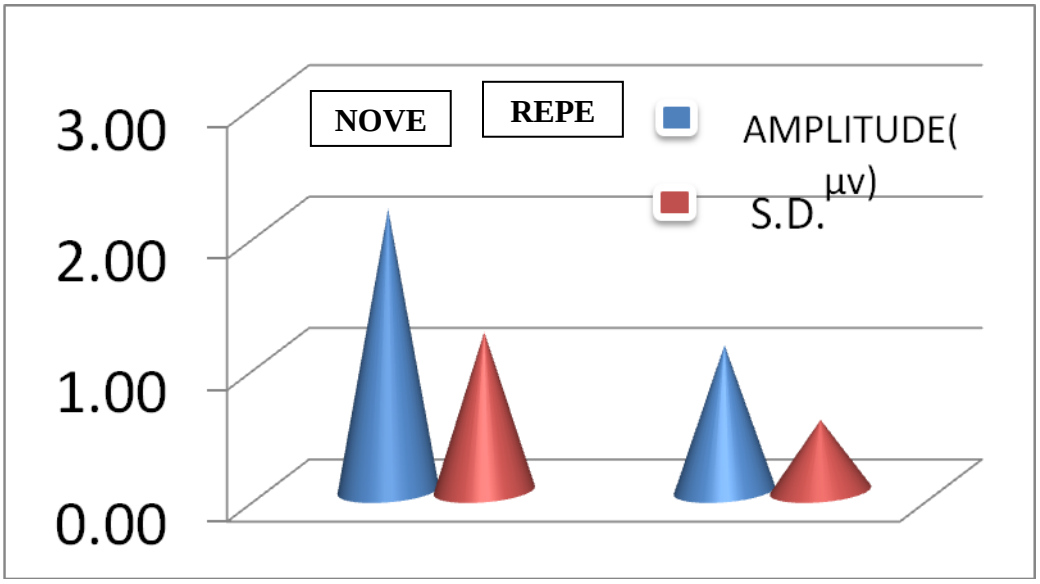


Figure – 2: Representing the mean P300 wave amplitude at Pz electrode site is significantly higher (P ≤ 0.001) with novel as compared to repeat stimulus.

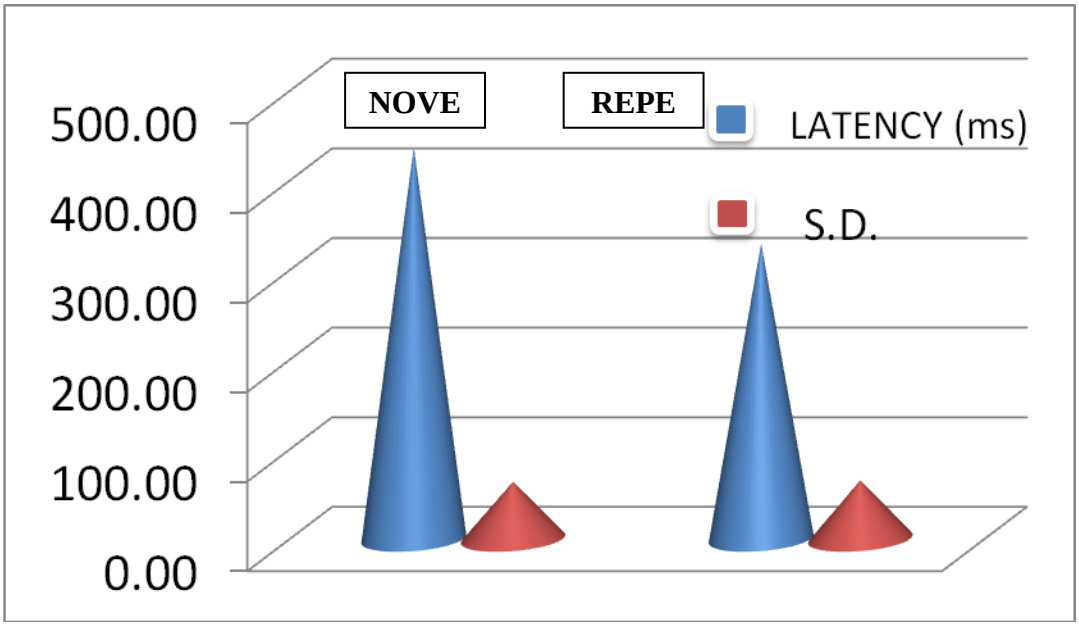


Figure – 3: Representing the mean P300 wave latency at Cz electrode site is significantly higher (P ≤ 0.001) with novel as compared to repeat stimulus.

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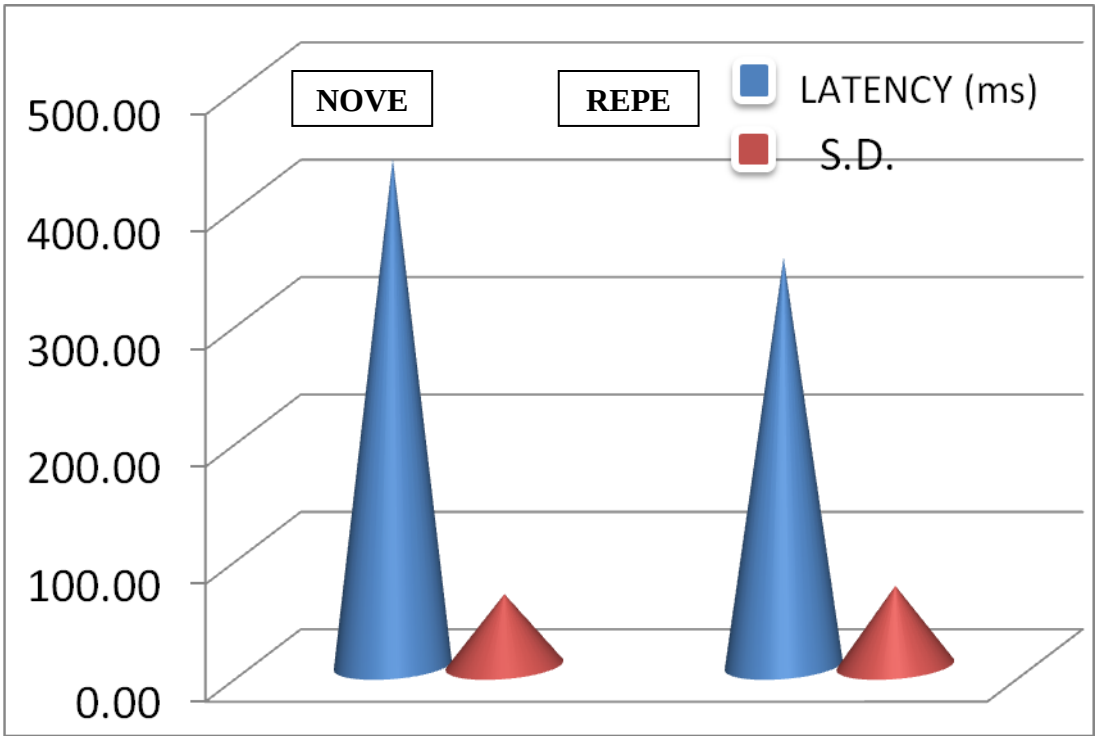

Figure – 4: Representing the mean P300 wave latency at Pz electrode site is significantly higher (P ≤ 0.001) with novel as compared to repeat stimulus.

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