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THE UNIVERSITY OF SOUTH FLORIDA
COLLEGE OF ARTS AND SCIENCES

Effect of Intensity Increment on P300 Amplitude

By

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An Audiology Doctoral Project submitted to the Faculty of the
Department of the Communication Sciences and Disorders
University of South Florida
In partial fulfillment of the requirements for the degree of

Doctor of Audiology

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Effect of Intensity Increment on P300 Amplitude

Tim Skinner

(Abstract)

The purpose of this study was to determine the effects of task difficulty on the amplitude and latency of the P300 by altering the intensity of the oddball stimulus. A P300 was obtained on 22 adult subjects ranging in age from 21 to 34 years of age (mean = 24 years) with normal hearing. The "frequent stimulus" was a 1000 Hz or 4000 Hz tone burst, gated with a rise and fall time of 10 msec and 20 msec plateau, presented at 75 dBn HL. The "oddball stimulus" was a tone burst of the same frequency (1000 Hz or 4000 Hz) presented at 77, 79, or 81 dBn HL. A four-channel recording was made with linked reference electrodes and the following montages: Cz-A1+A2, Pz-A1+A2, and Fz-A1+A2. The fourth channel was used to monitor "eye blink" activity. The investigation tested the null hypothesis that changing the intensity of the oddball stimuli would not result in a significant change in either the amplitude or latency of the P300.

Analyses of Variance (ANOVA) indicate that P300 latency and amplitude did not differ significantly by run, stimulus frequency, intensity of the oddball, or montage. Thus the null hypothesis was supported.

Introduction

The P300 (P₃) is an auditory evoked potential (AEP) referred to as a “cognitive” or “event-related response” occurring in the 300 msec latency region with a large positive voltage peak, hence “P”, after an acoustic stimulus. Like most long latency potentials (LLP), the P300 is an endogenous response, highly dependent upon subject attention to auditory stimuli. The P300 is typically recorded with the patient attending or listening for a rare, “oddball”, or target stimulus that is presented along with frequent stimuli. The stimulus that occurs the majority of the time is the “frequent stimulus” and the infrequent stimulus is known as the “oddball”. In the “oddball” test paradigm, two stimuli are presented with one occurring between 80% and 85% of the time and the other occurring between 15% and 20% of the time. The participant is asked to respond, usually by counting out loud or by pressing a button, when the oddball stimuli is perceived. The major peak is a large positive voltage (5 μ V) occurring approximately 300 msec after the rare or "oddball" response (Polich, 1996).

The P300 response is believed to reflect processing at the medial temporal lobe (hippocampus); however, the exact neural generators are not clear at this time (Molnar, 1994). It is known that the P300 response changes throughout the lifespan. Full maturity of the P300 does not occur until about 15 years of age. From birth through 15 years of age, latencies decrease, while amplitudes increase. The reverse is true from about 40 years of age through death; latencies slowly increase and amplitudes decrease.

The P300 is classified as an endogenous potential, meaning that it originates from within the subject and is dependent on the subject attending to or processing the stimuli. (Halgren, Marinkovic, & Chauvel, 1998). Unlike the auditory brainstem response (ABR), the P300 is not directly impacted by the stimulus characteristics. Attention and state of arousal are the two most important factors in eliciting a P300 response. In order to adequately assess the P300 response,

the subject must actively attend to the oddball stimulus and be able to discriminate it from the frequent stimulus. If the subject is unable to discriminate the oddball from the frequent stimulus, then the P300 will not be present (Hall, 1992). As the stimulus, both frequent and oddball, are reduced in intensity towards threshold, the amplitude of the P300 decreases (Papanicolaou et al., 1985; Covington & Polich, 1996; Sugg & Polich, 1995). Therefore, most P300 protocols use a 75 to 80 dB nHL stimulus intensity to decrease amplitude variability (Polich, 1998).

P300 amplitudes and latencies are used clinically to assess patients with Alzheimer's Disease, Parkinson's Disease, and dementia. Patients with these neurodegenerative disorders tend to have prolonged P300 latencies, believed to be related to changes in neurotransmitters (Kugler, Taghavy, & Platt, 1993). The P300 can be extremely valuable tool when evaluating general cognitive function (Polich & Herbst, 2000). P300 latencies have been shown to increase, while amplitudes decrease, with decreases in cognitive function (Polich, Howard, & Starr, 1983).

It is important, from both clinical and research perspectives, to design paradigms that will improve the utility of the P300. In 1995, Sugg and Polich found that the discrimination task needs to be difficult enough to elicit a P300 response. They found that if the discrimination task is too simple (> 7 dB or > 50 Hz), the amplitude decreases while the latency increases. The P300 also becomes less reliable outside of those parameters. Since the characteristics of the P300 are affected by cognitive processing, theoretically, the more difficult the oddball task, the greater the amplitude of the P300 response. The proposed study was designed to determine if a simple psychoacoustic ability can be measured electrophysiologically. The psychoacoustic ability of interest for this study was intensity discrimination.

Intensity discrimination thresholds are dependent on the frequency and sensation levels of the stimuli (Turner, Zwislocki, & Fillion, 1989). Intensity difference limens decrease as the sensation levels are increased (Yost, 1994). The intensity discrimination for a normal hearing

adult for a stimulus with a sensation level above 60 dB HL is less than 1 dB (Gelfand, 1998).

The purpose of this study is to determine the effects of changing the difficulty of the discrimination task on the amplitude and latency of the P300 by altering the intensity of the oddball stimulus.

Methods

Participants

Twenty-two participants (5 males and 17 females) between the ages of 21 and 34 years (mean = 24 years of age) participated in this study. All participants in this study were required to have normal hearing and normal middle ear function with no known neurological or cognitive disorders. Normal hearing was defined as air conduction thresholds at or below 20 dB HL for the frequencies 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz in each ear (American National Standard Institute, 1996; American Speech-Language and Hearing Association, 1985). Normal middle ear function was defined as an ear canal volume between 0.5 ml and 2.0 ml, a peak pressure between -150 daPa and +100 daPa, and a compliance value between 0.2 ml and 1.8 ml. Contralateral acoustic reflexes were measured and were required to fall within normal limits determined by the published acoustic reflex threshold 90% cutoff values (Silman & Gelfand, 1981). These criteria for inclusion were used in order to make the group as homogenous as possible. The participants were not financially compensated.

Instrumentation

Air conduction thresholds were measured using an Interacoustics (Model AC40) audiometer and middle ear function was determined using a GSI Tymptstar. For P300 measures, stimulus presentation and signal averaging were controlled by a Nicolet *Spirit* evoked potential system. All equipment used was calibrated according to ANSI specifications.

Materials and Procedures

The hearing test and middle ear measures were conducted at the Communication Sciences and Disorders Audiology Clinic at the University of South Florida. The P300 testing was conducted in a research laboratory in the Department of Communication Sciences and Disorders using a Nicolet Spirit evoked potential system. The “frequent stimulus” used was a 1000 Hz or 4000 Hz tone burst, gated with a rise and fall time of 10 msec and a 20 msec plateau, presented at 75 dBn HL. The “oddball stimulus” was a tone burst of the same frequency (1000 or 4000 Hz) presented at 77, 79, or 81 dBn HL. The “frequent” tone bursts were presented in a stimulus train with a probability of 80% while the “oddball” tone bursts occurred with a probability of 20% within the stimulus train. Rarefaction was used as the polarity and the time window was 600 msec. The responses were band pass filtered between 1 and 30 Hz. Thirty responses for each oddball were averaged and constituted one run. The tone bursts were presented binaurally through ER-3 insert earphones at a rate of 0.77 per second. A four-channel recording was made with linked reference electrodes and the following montage: Cz-A1+A2, Pz-A1+A2, and Fz-A1+A2. The fourth channel was used to monitor "eye blink" activity. If the amplitude of the fourth channel exceeded 5 μ V in the region of the P300, the run was discarded. The forehead (Fpz) was used as the ground. Impedance was maintained below 2000 ohms. The P300 measures took place in a double walled IAC sound treated room. The starting oddball intensity was counterbalanced. Participants were instructed to respond to the oddball stimulus by pressing a button that they were given. The patient response button was unattached, but the participant did not have knowledge of this. P300 amplitude and latency for each oddball were recorded for each subject. All subjects were involved in two runs for each stimulus frequency and intensity combination for a total of 12 runs. All of the runs and the initial hearing test were completed in one session.

Results

Figure 1 displays the mean audiometric thresholds for all participants. Figures 2a and 2b display the mean (± 1 SE) amplitude for each intensity level by electrode montage. In order to determine

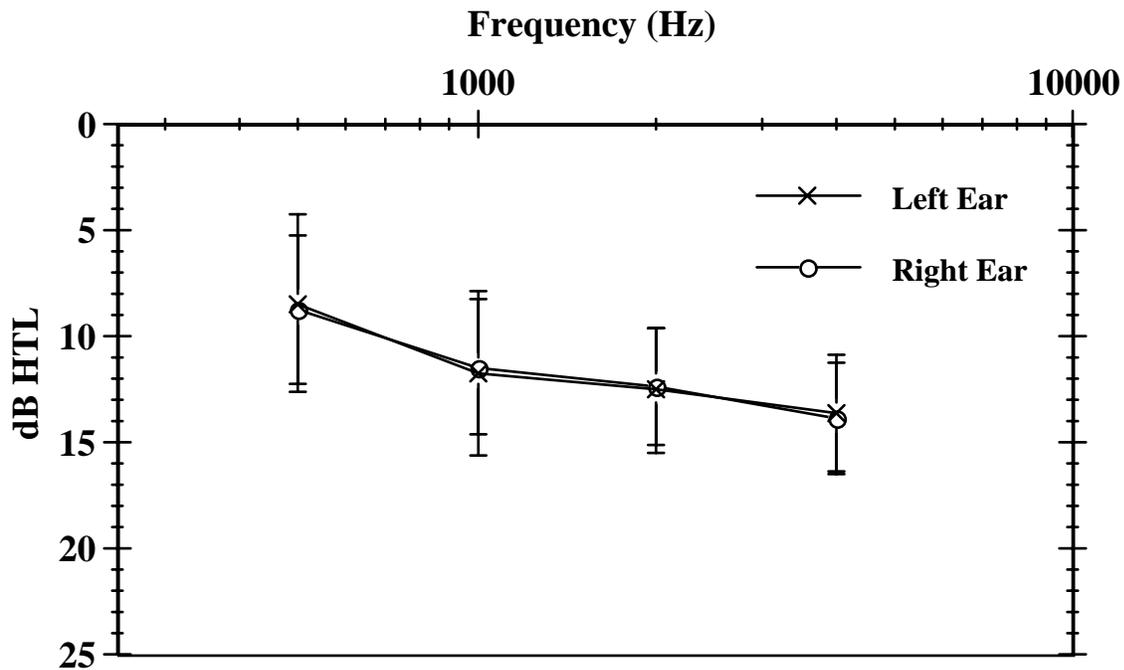
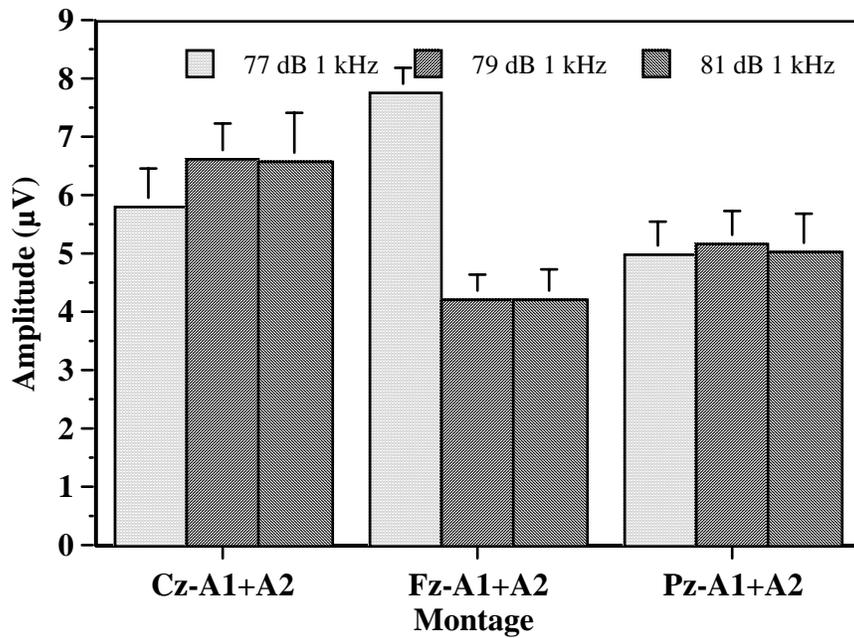
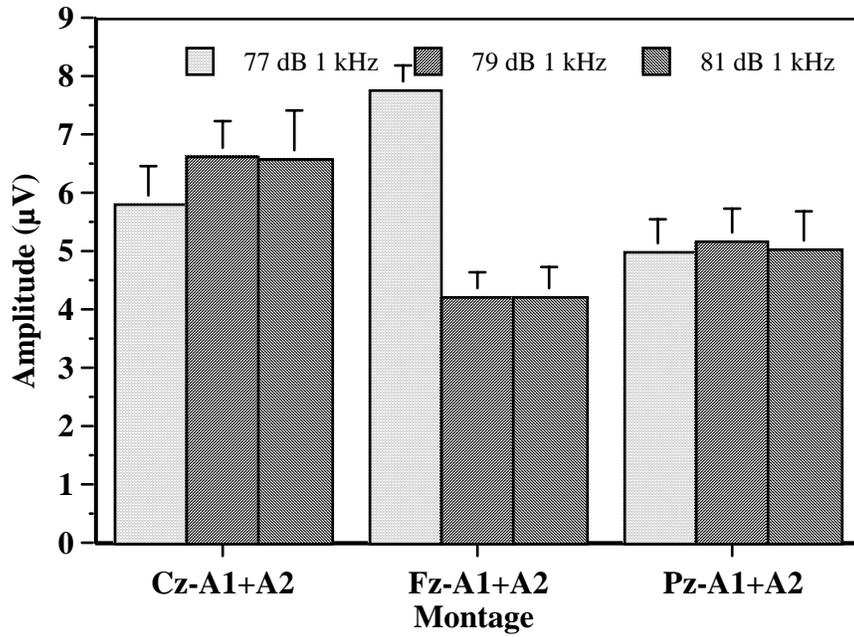


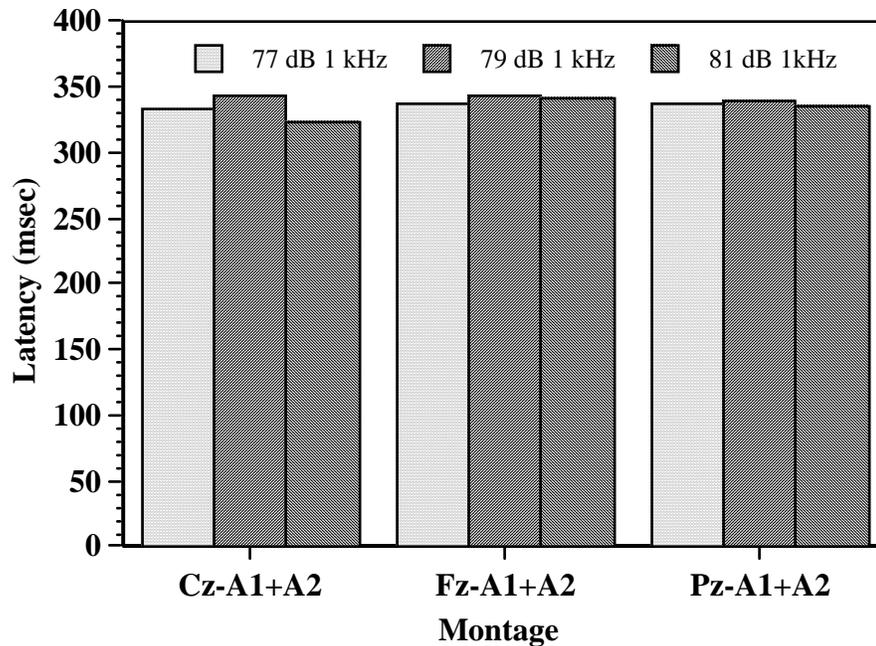
Figure 1. Mean (± 1 SD) hearing thresholds levels (HTLs) for all participants

if these mean data were significantly different, the data were analyzed using a 4-way Analysis of Variance (ANOVA) with four within subjects variables (run, frequency, intensity of the oddball, and montage). For amplitude, only one interaction reached statistical significance, that between run and frequency [$F(1,21) = 4.33, p = 0.05$]. A Tukey post-hoc analysis of the significant interaction between run and frequency revealed that none of the possible combinations of run and frequency differed significantly from each other ($p > 0.05$).



Figures 2a and 2b. Mean (± 1 SE) P300 amplitude at the three electrode montages for the three intensity levels at 1000 and 4000 Hz.

Figures 3a and 3b illustrate the mean latency for each intensity level by electrode montage. In order to determine if these mean data were significantly different, the data were analyzed using a 4-way ANOVA with four within subjects variables (run, frequency, intensity of the oddball, and montage). None of the main effects (run, frequency, intensity of the oddball, and montage) or interactions were significant ($p > 0.05$).



Figures 3a. Mean (± 1 SE) P300 latency at the three electrode montages for the three intensity levels at 1000 Hz. The SE values are so small that the error bars are not visible on this figure.

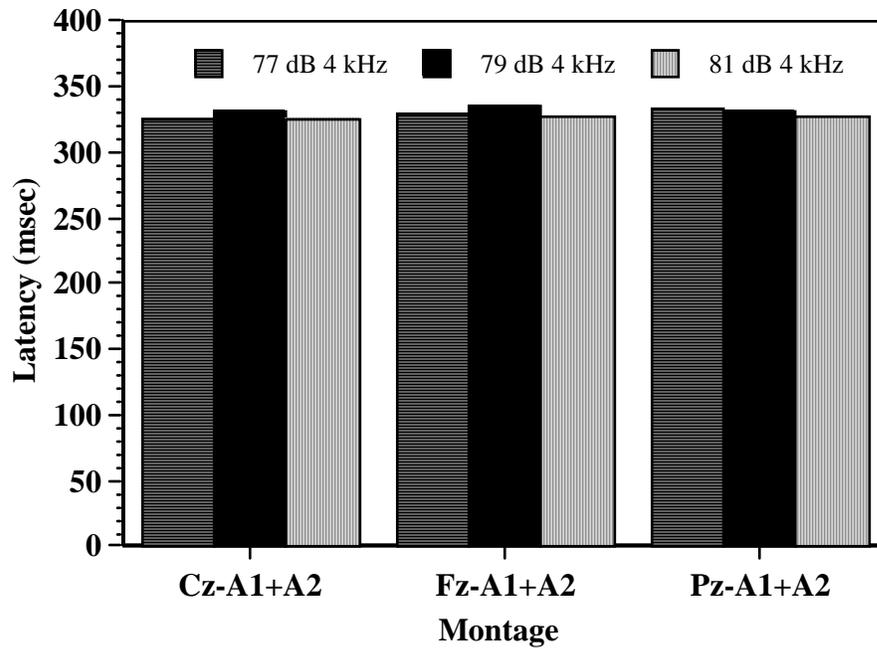


Figure 3b. Mean (± 1 SE) P300 latency at the three electrode montages for the three intensity levels at 4000 Hz. The SE values are so small that the error bars are not visible on this figure.

Figures 4 and 5 display the mean (± 1 SE) test – retest raw data for run 1 versus run 2 for amplitude and latency respectively. There were no significant differences between run 1 and run 2 for either amplitude or latency as analyzed using the two 4-way ANOVAs described above.

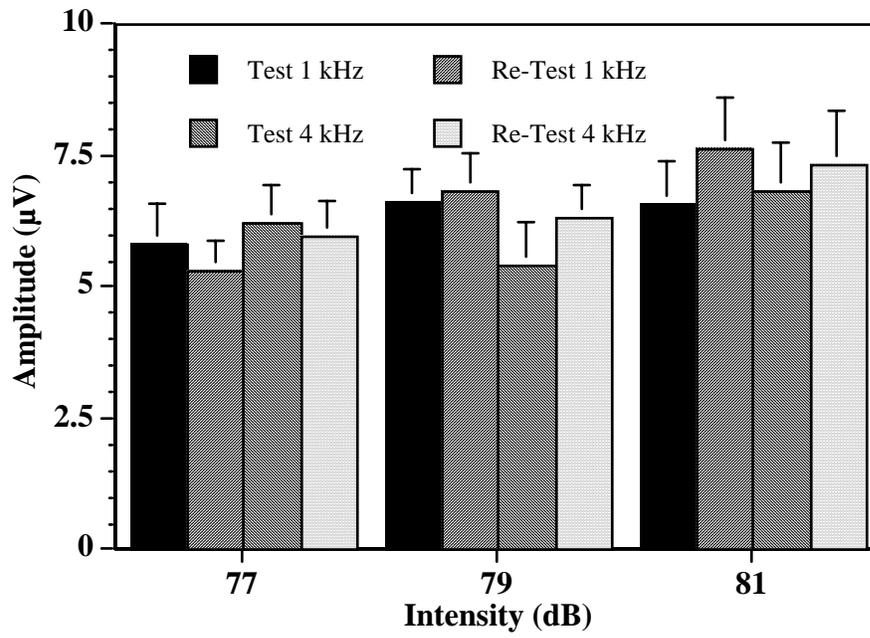


Figure 4. Mean (± 1 SE) P300 test-retest amplitude for the three intensity levels at 1000 Hz and 4000 Hz.

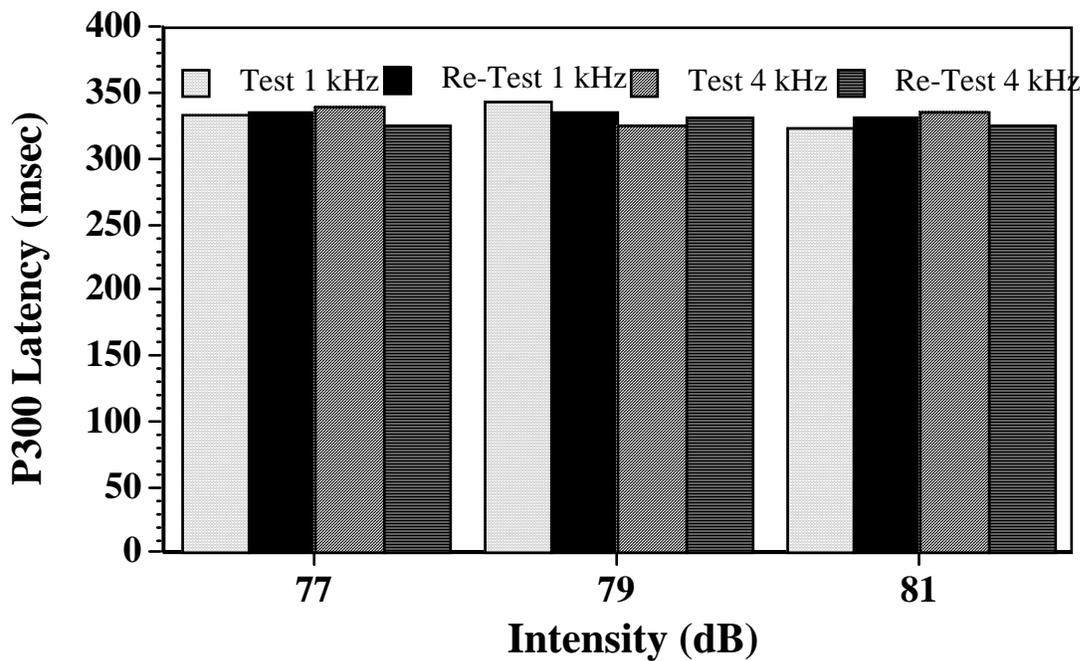


Figure 5. Mean (± 1 SE) P300 test-retest latency for the three intensity levels at 1000 Hz and 4000 Hz. The SE values are so small that the error bars are not visible on this figure.

There were no statistically significant effects seen in any of the analyses of the data associated with this experiment. We originally hypothesized that changing the intensity of the oddball stimuli would not result in a change in either the amplitude or the latency of the P300. According to the data and analysis above, our hypothesis is supported.

Discussion

Though it has been proposed that the amplitude and latency of the P300 is affected by the difficulty of a discrimination task, this study has found that this is not the case (Sugg & Polich, 1995). Previous studies have demonstrated that the P300 is influenced by cognitive factors (Polich & Herbst, 2000; Kugler, Taghavy, & Platt, 1993), suggesting a potential clinical application. This study explored the clinical utility of the P300.

This study investigated the effect of the magnitude of the intensity difference between the frequent and oddball stimulus on the amplitude and latency of the P300. The results indicated that the intensity difference between the frequent and oddball stimulus had no effect on either the latency or the amplitude of the P300. Further, the P300 did not vary as a function of the electrode montage. There are several possible reasons that the manipulation of the intensity difference between the frequent stimulus and the oddball stimulus did not affect the amplitude or the latency of the P300. First, the P300 is believed to reflect processing that occurs primarily at the level of the medial temporal lobe (Molnar, 1994). The intensity discrimination task used in this study may be processed at a lower level of the auditory pathway. If the stimulus is processed at a lower level, then the P300 may be unaffected. Second, the intensity discrimination task may not have been difficult enough to make it cognitively challenging enough to affect the P300. Different psychoacoustic tasks should be used in future testing to assess the hypothesis of this study.

Summary

The present study suggests that the P300 is unaffected by changes in the intensity difference between the frequent and oddball stimulus. More research is needed to completely understand the neural generators that are involved in the formation of the P300. Different paradigms also need to be designed to help increase the clinical utility of the P300. Although the intensity discrimination task did not result in any changes to the P300, other tasks such as frequency discrimination or gap detection may prove to be useful.

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