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Degree Type
Thesis

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Produced by Viewing a Simulated Traffic Signal

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The P-300 event related brain potential was monitored during simulated traffic signal tasks for ten subjects who were tested at three levels of mean Blood Alcohol Content (BAC): 0.00%, 0.06%, and 0.13%. A significant increase in latency occurred for the 0.13% BAC level indicating that an increased mental processing time was required to determine if a red or a green light had been presented.

Suggested Running Heading: Alcohol versus P-300

KEYWORDS: latency, ethanol, mental processing, driving, P-3, P-300, P300.

INTRODUCTION

The decision to stop at a red traffic light is made quickly and correctly by most automobile drivers - unless they are intoxicated or impaired. Then the appropriate response can take much longer and disastrous consequences often result. (1-3) Using driving simulators, many experiments have shown that alcohol slows motor reaction times (4-8), but few studies have attempted to investigate the effects of alcohol on the mental processing necessary to evaluate the information conveyed by the traffic signal as separate from motor responses necessary to stop a vehicle.

It has recently been shown that mental processing of the information contained in a stimulus can be assessed by using an electroencephalographic (EEG) event-related potential known as the P-300.* (9-11) The designation P-300 is derived from the positive polarity of the signal as recorded at the scalp and from the fact that in many experiments the time between the presentation of the stimulus and the peak of the response is about 300 ms. (12-15) (The term P-300 can be somewhat misleading, however, since in some experiments the latency can be much longer than 300 ms; following convention the term P-300 will be used in this paper.)

The P-300 is most often elicited experimentally using an "oddball" paradigm in which a series of similar, repetitive stimuli (visual, auditory, etc.) are presented to the subject. (9-11) This establishes an "expectation set" or "template" in short-term memory. (16) Each subsequent stimulus is compared to this template and if the stimulus fits, all is well. But, if a novel or unexpected

stimulus is encountered, the brain detects a mismatch and a P-300 is generated. In P-300 odd-ball experiments, unusual stimuli (odd-balls) are inserted at random into a series of repetitive stimuli and the P-300 responses to the odd-balls are computer averaged to form a composite P-300 wave.

Several factors can affect the amplitude of the P-300. (9-11, 17) It can be decreased by increasing the frequency of trials on which the unique stimulus is presented, by distracting the subject from the task, by adding to her concurrent work-load to reduce the amount of attention she is able to pay to the stimuli, or by decreasing the perceived importance of the task.

The latency of the P-300 is related to the time it takes for the subject to process the informational content of the stimulus and to conclude that it is unique. (12-15) Latencies can be increased by making it more difficult to discriminate the frequent from the unique stimuli. (18) Thus, the P-300 has been suggested as a mental chronometer.

The latency and amplitude shifts that can be produced in the P-300 wave suggest its usefulness as an indicator of the mental changes that result from the consumption of alcohol. (19-22) Many studies, especially those involving driving simulators, have shown that reaction times increase with alcohol consumption. However, the time required to react to a stimulus in a driving simulator is a function of many things including the evaluation of the informational content of the stimulus, the decision regarding the proper motor activities required by the stimulus, initiation of these

motor activities by the central nervous system and finally the actual physical response itself. By using the P-300, the first of these steps can be isolated.

In the experiment described below, we investigated the effects of alcohol consumption on the processing of simple visual stimuli. To relate the project to a driving situation, subjects viewed a stimulated traffic light which was green for 80% and red for 20% of the trials. P-300's produced by the red stimuli were recorded and evaluated to determine effects of differing levels of intoxication on mental processing. Our goals were to show that alcohol slows mental processing in a driving simulation task and to further demonstrate the usefulness of the P-300 as a mental chronometer.

METHODS AND MATERIALS

Subjects

Ten volunteer students from the Pacific University College of Optometry participated in this experiment (seven males and three females, age range from 21 to 35). All subjects were in normal health, had visual acuity corrected to 20/20 and reported having previously consumed alcohol in social settings. All completed an appropriate Informed Consent Form and were properly monitored following the experiment to prevent injury while in an intoxicated condition.

Alcohol

Alcoholic beverages were administered by the Forest Grove Police Department. Subjects drank 8-ounce beverages of their choice

containing 1.25 ounces of 80 proof alcohol and 6.75 ounces of mixer. They consumed sufficient amounts of alcohol to elevate their Blood Alcohol Content (BAC) to about .05 in 1.0 H and .10 level in about 2.5 H. The number of drinks each subject consumed was adjusted for her/his body weight. At the 1.0 and 2.5 H intervals, each subject's actual BAC was measured using an Intoxilyzer Model 4011A breath alcohol analyzer.

Stimuli

To elicit P-300 responses, stimuli were presented on an Apple IIe controlled Zenith 135 RGB video monitor with the subjects seated 50 cm in front of the screen. The initial display consisted of a vertically centered white rectangle 7.0 cm x 4.0 cm with a smaller black fixation rectangle centered within the larger rectangle. This background display remained constant during the study.

At random times (with maximum limits of 4.0 to 7.0s between trials), either a red or a green square (2.5 cm x 2.5 cm) was superimposed for 50 ms on the white background. When the red square appeared, it was located above the fixation rectangle and when the green square was presented it was below. In this way, the stimulus simulated a traffic signal with which all subjects were well familiar. The white background and the colored stimuli were well above the photopic threshold and were easily seen by all subjects. Thus, detectability of the stimuli was not a significant factor in this experiment.

The Apple computer was programmed to present either the green stimulus or the red stimulus according to a pseudo-random sequence

such that on approximately 20% of the trials the red light was presented. Trials continued for approximately three minutes, until 20 red lights had been presented.

During the trials, the subjects were instructed to fixate the central target and mentally count the number of times the red light appeared. To maintain attention and motivation throughout the trials, the subjects were given feedback on the correctness of their counts.

Signal Recording and Analysis

P-300 signals were recorded using conventional procedures. Silver/silver chloride electrodes were placed at scalp location Pz, on the forehead (ground), and on the earlobes (link to form the reference electrode). Resistence between the electrodes was 5 k-ohms or less. EEG signals were amplified with a Gould Universal Isolator Amplifier using frequency cut-off points of 1.0 and 30 Hz.

Two hundred milliseconds before a red stimulus was to be presented, the Apple IIe computer signaled a Data General Nova 800 computer to begin digitizing and storing data from the subject. Digitization took place every 2.0 ms for a total of 1024 ms. Data from the twenty presentations of the red stimulus were ensemble averaged and smoothed using a 3-point averaging filter to produce the P-300 for the subject. Figure 1 shows an example of a P-300

Insert Figure 1 about here

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wave form. The P-300 is the third major positive peak as identified by the arrow.

The latency of the P-300 was measured from the onset of the red stimulus to the peak of the P-300 wave. The amplitude was measured from the mean of the background activity occurring during the 200 ms pre-stimulus interval to the peak of the P-300 wave.

RESULTS

Blood Alcohol Levels

P-300's were measured from each subject three times during the course of the experiment. BAC levels are shown on Table 1.

Insert Table 1 about here

For the intermediate BAC condition, subjects would not have been legally intoxicated in most states, but for the high BAC condition, all would have been.

Stimulus Counts

Subjects were asked to keep a mental count of the number of red stimuli presented in each measurement session. No subject's count was off by more than one except for one subject who was off by two in the baseline condition. Thus, subjects detected essentially all of the red flashes so any changes in P-300's between BAC conditions cannot be attributed to simple inability to detect the unusual stimuli.

P-300 Latencies

Mean P-300 latency (Table 1) increased along with BAC. While the increase of 7.7 ms between baseline and intermediate BAC conditions is not significant ($t = 0.703$; $df = 9$; $p > .05$; matched

groups t-test), the increase from the intermediate to the high BAC condition is significant ($t = 4.086$; $df = 9$; $p < .05$, matched group t-test). The increase from the baseline to the high condition is also significant ($t = 6.298$; $df = 9$; $p < .05$, matched groups t-test).

P-300 Amplitudes

Table 1 shows that the mean P-300 amplitudes did not change significantly as a function of BAC. The 0.08 uV amplitude increase from baseline to intermediate BAC is not significant ($t = -.518$; $df = 9$; $p > .05$ matched groups t-test), nor is the 0.70 uV decrease from the intermediate to the high BAC ($t = 2.04$; $df = 9$; $p > .05$ matched groups t-test).

DISCUSSION

It takes 63 ms longer for an intoxicated subject to evaluate the informational content of a simple stimulus such as the red light used in this experiment. If our subjects had been driving automobiles at 55 mph, they would have traveled an additional one-half car length (5.08 feet) during this time decision time. In an emergency situation this, could well mean the difference between a safe stop and a disaster.

Why does P-300 latency increase as a function of blood alcohol? Several possible explanations for this effect can be ruled out easily. First, since it is known that blur affects P-300 latency, (18) it might be suggested that the intoxicated subjects were unable

to see the display screen clearly. Second, it might be suggested that intoxicated subjects looked away from the screen or had their eyes closed during a significant portion of the experiment. Finally, it is possible that the intoxicated subjects were not motivated to count the red squares and this reduction in motivation could have affected the P-300 latency. None of these factors is a likely explanation for the latency increase. The large size of the colored stimuli makes it unlikely that blur affected the ability of the subjects to detect them. Beyond this, the accuracy of the stimulus counts provided by the subjects indicates that they saw essentially all of the red flashes. Additionally, while subjects may have been less motivated in the intoxicated condition, the amplitude of the P-300 is generally considered to be a good indicator of task motivation and amplitude did not decrease significantly as a function of BAC.

A factor which is not so easily ruled out involves the effect of alcohol on body temperature. Several researchers (19-22) have suggested that as body temperature increases, latencies of evoked potentials change. Others have raised questions about the significance of the body temperature change, but this remains a possible explanation for the latency shift found in this study. Other explanations involve vague concepts such as slowing of "mental processing" or "confused thinking" which are difficult to define operationally or physiologically.

The goal of this study was to demonstrate that the P-300 can be used as a mental chronometer to assess the effects of alcohol on information processing. This goal was met. P-300 latencies increased significantly with BAC, and, while this study did not reveal the mechanism by which this increase took place, it does add emphasis to the warning about avoiding alcohol in situations where rapid mental decisions must be made.

FOOTNOTE

*The P-300 is not specifically related to the sensory system via which it is elicited, thus the stimuli can be auditory, visual, tactile, etc. The P-300 is, therefore, considered an endogenous, event-related potential related to processing of the information content of the stimulus. This distinguishes it from other evoked potentials, such as the visual evoked response (VER), which are produced by the stimulus itself and thus are referred to as exogenous potentials.

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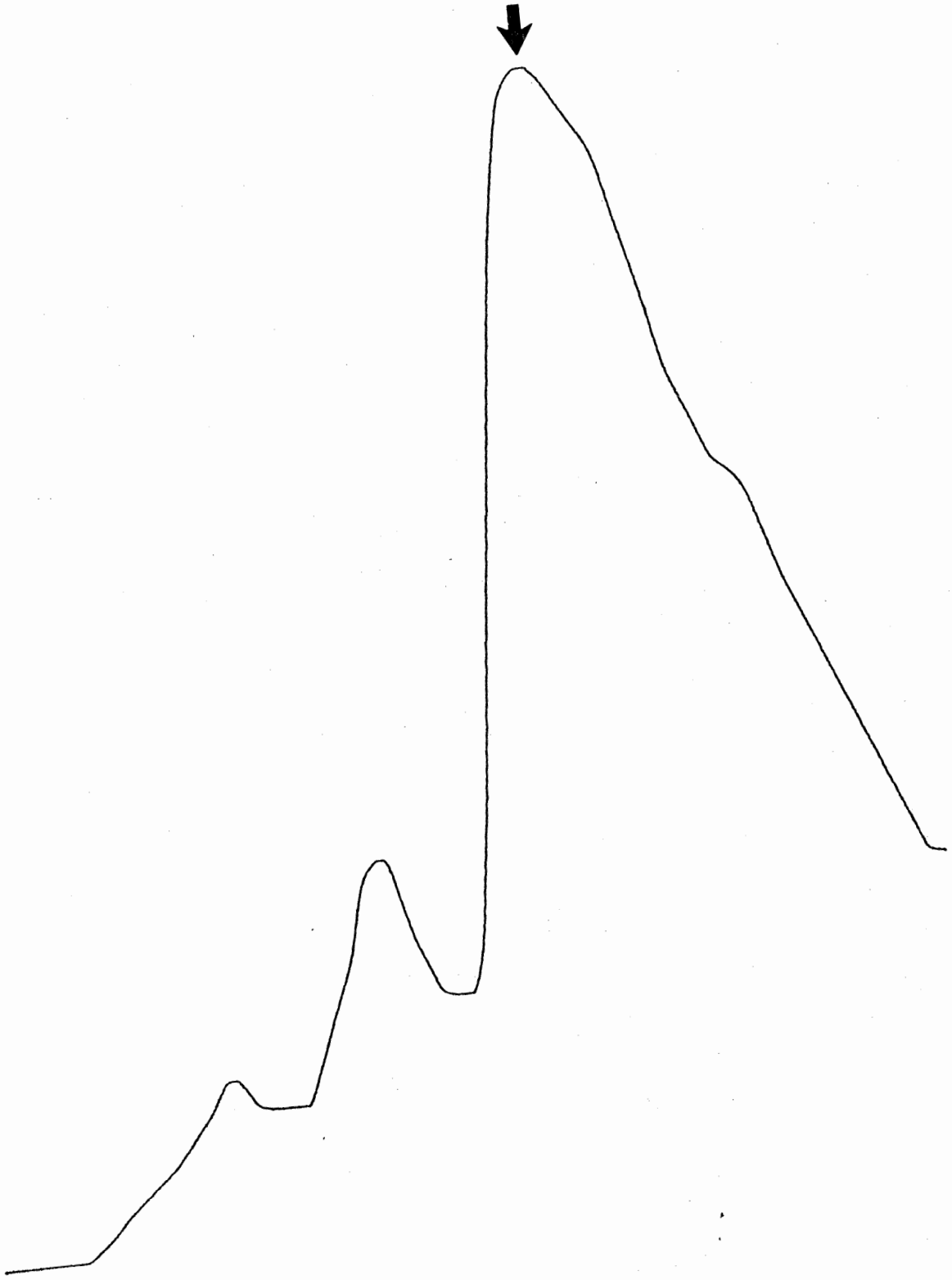

Figure 1

Table 1

	Condition		
	Baseline	Intermediate	High
Mean BAC (%)	0.00	0.06	0.14
SD	--	0.012	0.02
Range (%)	--	0.05-0.08	0.11-0.17
Mean Latency (ms)	365.1	372.8	428.1
SD	44.8	36.8	53.1
Mean Amplitude (uV)	4.72	4.80	4.10
SD	0.57	0.60	1.10