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Brain Wave Correlates of Attentional States: Event Related Potentials and Quantitative EEG Analysis During Performance of Cognitive and Perceptual Tasks

by

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Abstract

The increased use of automation in the cockpits of commercial planes has dramatically decreased the workload requirements of pilots, enabling them to function more efficiently and with a higher degree of safety. Unfortunately, advances in technology have led to an unexpected problem: the decreased demands on pilots have increased the probability of inducing "hazardous states of awareness". A hazardous state of awareness is defined as a decreased level of alertness or arousal which makes an individual less capable of reacting to unique or emergency types of situations. These states tend to be induced when an individual is not actively processing information. Under such conditions a person is likely to let his/her mind wander, either to internal states or to irrelevant external conditions. As a result, they are less capable of reacting quickly to emergency situations. Since emergencies are relatively rare, and since the highly automated cockpit requires progressively decreasing levels of engagement, the probability of being seduced into a lowered state of awareness is increasing. This further decreases the readiness of the pilot to react to unique circumstances such as system failures. The HEM Lab at NASA-Langley Research Center has been studying how these states of awareness are induced and what the physiological correlates of these different states are. Specifically, they have been interested in studying electroencephalographic (EEG) measures of different states of alertness to determine if such states can be identified and hopefully, avoided.

The study of EEG in the HEM lab has involved two basic aspects of brain waves. First, there is the quantitative analysis of EEG recorded from 21 different electrode sites on the scalp. Basically, EEG is recorded and a Fast Fourier Analysis is performed on the recordings. When someone is drowsy, alpha waves (8-13 Hz) are typically seen, especially over the occipital lobe of the brain. When a person is awake and aroused, beta waves (13-30 Hz) are observed. With the use of the EEG brain mapper in the HEM Lab, different patterns of arousal across the cortex can be assessed and related to different categories of alertness.

The second basic aspect of brain waves are event related potentials (ERPs). These are electrical responses to discrete visual or auditory conditions presented to the subject as task-relevant or task-irrelevant stimuli. Over the course of 500-1000

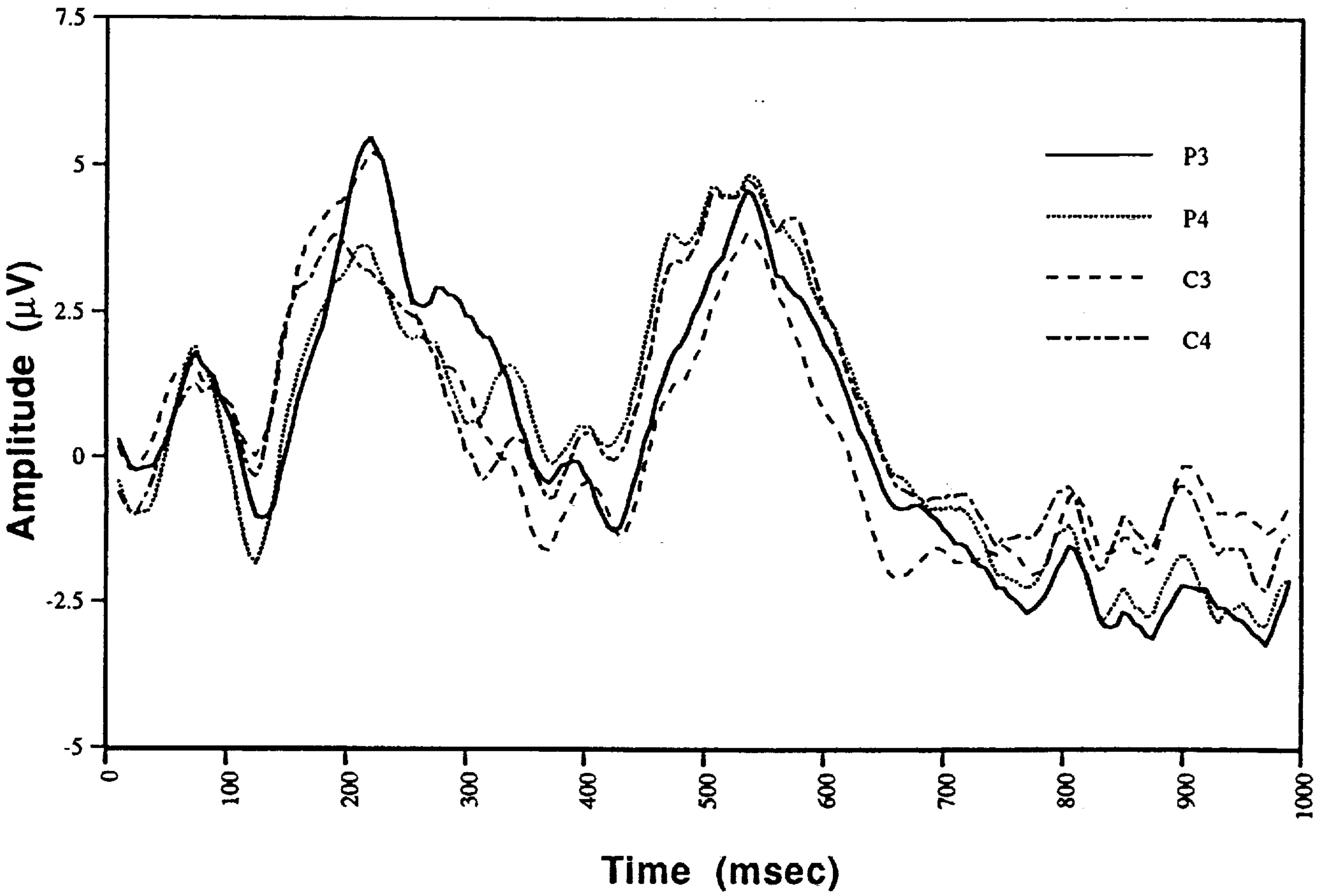
msec, different waveforms can be seen which reflect levels of attention and awareness.

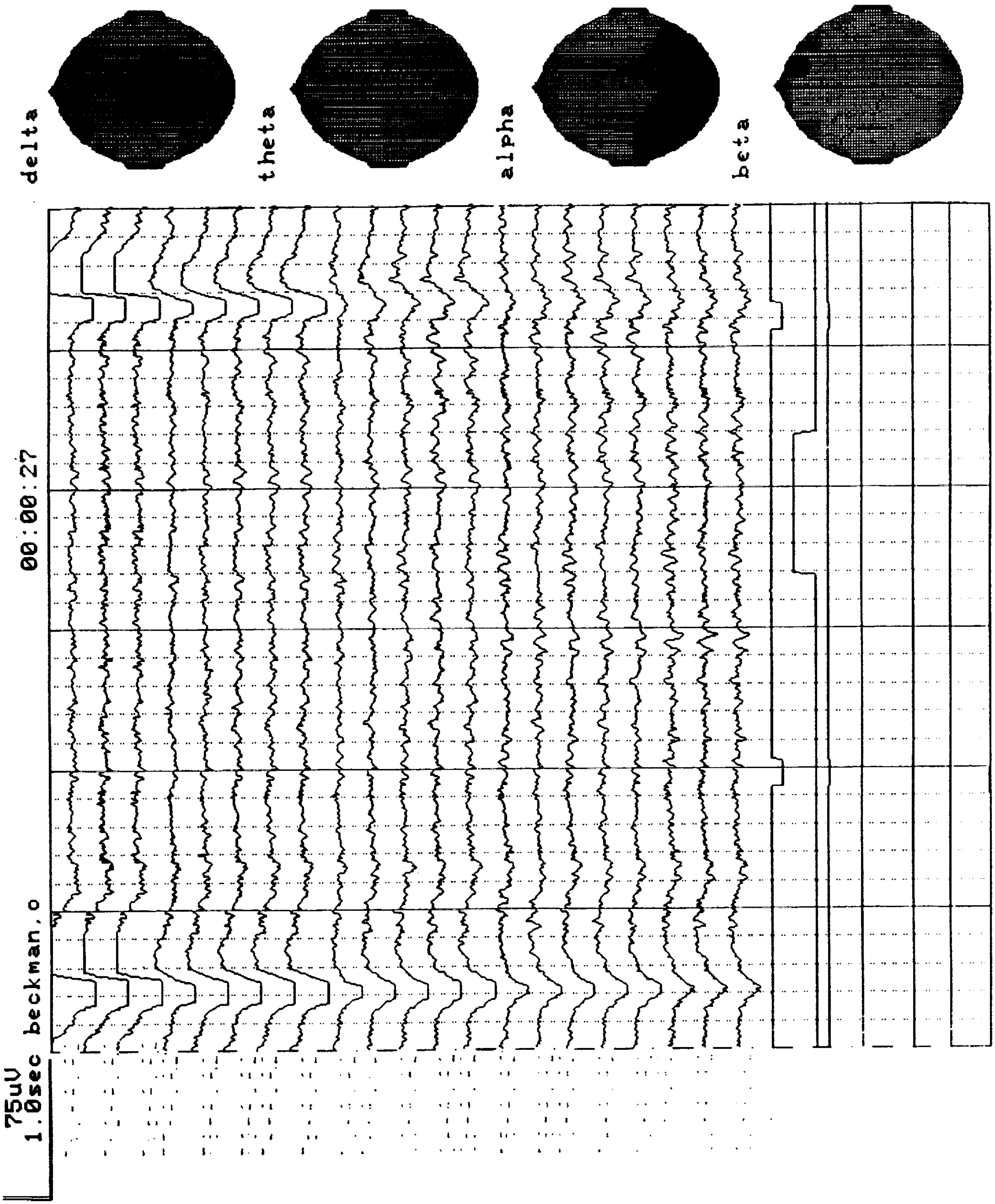
The project worked on this summer involved analyzing the EEG and the ERP data collected while subjects performed under two conditions. Each condition required subjects to perform a relatively boring vigilance task. The purpose of using these tasks was to induce a decreased state of awareness while still requiring the subject to process information. Each task involved identifying an infrequently presented target stimulus. In addition to the task requirements, irrelevant tones were presented in the background. Research has shown that even though these stimuli are not attended, ERPs to them can still be elicited. The amplitude of the ERP waves has been shown to change as a function of a person's level of alertness. ERPs were also collected and analyzed for the target stimuli for each task. Brain maps were produced based on the ERP voltages for the different stimuli. In addition to the ERPs, a quantitative EEG (QEEG) was performed on the data using a Fast Fourier technique to produce a power spectral analysis of the EEG. This analysis was conducted on the continuous EEG while the subjects were performing the tasks. Finally, a QEEG was performed on periods during the task when subjects indicated that they were in an altered state of awareness. During the tasks, subjects were asked to indicate by pressing a button when they realized their level of task awareness had changed. EEG epochs were collected for times just before and just after subjects made this response. The purpose of this final analysis was to determine whether or not subjective indices of level of awareness could be correlated with different patterns of EEG.

In Figures 1 and 2 can be seen some representative results. ERPs to the target stimuli can be seen in Figure 1. The four lines represent recordings from different cortical sites. "C" stands for electrode placements over the central part of the skull while "P" stands for placements over the parietal lobes. Odd numbers are for placements over the left hemisphere and even numbers the right hemisphere. The data demonstrate a larger positive wave around 200 msec over the right hemisphere. In Figure 2 is shown a reprentative epoch of the EEG and accompanying maps recorded during one of the tasks. The maps demonstrate the amount of power in each wave band. Lighter areas of the maps indicate more power for the band.

The research described represents part of a systematic investigation concerning "hazardous states of awareness". Future research will involve different methodologies for assessing subjective states and correlating them with EEG and behavioral measures.

ERPs Perceptual Task Target Stimulus

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