

## Reference

Levendowski, D.J., Berka, C., Olmstead, R.E., Konstantinovic, Z.R., Davis, G., Lumicao, M.N., Westbrook, P: Electroencephalographic indices predict future vulnerability to fatigue induced by sleep deprivation. Sleep 2001;24(Abstract Supplement): A243-A244 (Presented at the APSS Sleep Conference June, 2001 in Chicago)

## **ELECTROENCEPHALOGRAPHIC INDICES PREDICT FUTURE VULNERABILITY TO FATIGUE INDUCED BY SLEEP DEPRIVATION**

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### **Introduction:**

Electroencephalographic (EEG) parameters are sensitive indicators of drowsiness and have been proven to correlate with performance on a second-by-second basis (Makeig, 1995). This study applies the B-Alert system, a discriminant function analysis (DFA) model designed to classify one-second epochs of EEG on a continuum from highly vigilant to sleep onset to quantify the effects of partial sleep deprivation. The system was designed to provide real-time detection of drowsiness and recommend the optimal time to take a short nap to extend vigilance.

### **Methods:**

Forty-nine healthy subjects (males = 32, females = 17; age range 25 – 68) participated in a 12-hour overnight study 14 hours after they awakened from partial sleep deprivation. Continuous EEG and EOG recordings were acquired from the subjects during fully-rested baseline and overnight sessions. Two-choice Psychomotor Vigilance Tests (PVT-ABM) were administered at baseline and 15, 19, 23, and 25-hours after waking from partial sleep deprivation (Maximum reaction time cut-off = 1.5 seconds). EEG classifications, reaction times and percentage correct responses were averaged across each of the PVT-ABM sessions. Differential recordings for CzPz and CzOz were obtained with disposable Ag/AgCl electrodes. EEG and EOG were acquired with Teledyne amplifiers, low pass filter at 75 Hz and high pass filter at 0.5 Hz, fixed gains at 10,000 and 2,000, respectively. EEG classification results were collapsed into high vigilance and drowsy categories.

This study was not designed to assess the effects of napping as a countermeasure. In an effort to ensure all subjects completed the study, however, 35 subjects were allowed a short nap approximately 20.5 hours after awakening from partial sleep deprivation based on technician observations of fatigue. The remaining 14 subjects did not exhibit sufficient fatigue at the scheduled napping time and completed the protocols without a nap.

### **Results:**

Repeated measures ANOVA revealed a significant decrease in high vigilance classifications, a significant increase in drowsy classifications, and a significant interaction between the two as a function of time elapsed after awakening from partial sleep deprivation. The percentage of correct PVT-ABM responses decreased significantly and the PVT-ABM reaction time increased significantly as a function of time. EEG classifications for subjects requiring naps (“Nappers”) showed a distinctive pattern when compared to “No-Nappers”. The Nappers evidenced a rapid increase in drowsy epochs with a steep decline in high vigilance epochs (Fig. 1.a.). The No-Nappers showed similar but less pronounced trends; the drowsy and high vigilant epochs were less affected even at the 25-hour time point (Fig. 1.b.). PVT-ABM reaction times (Fig. 2.a.) and percentage correct responses (Fig. 2.b.) closely paralleled the B-Alert classifications.

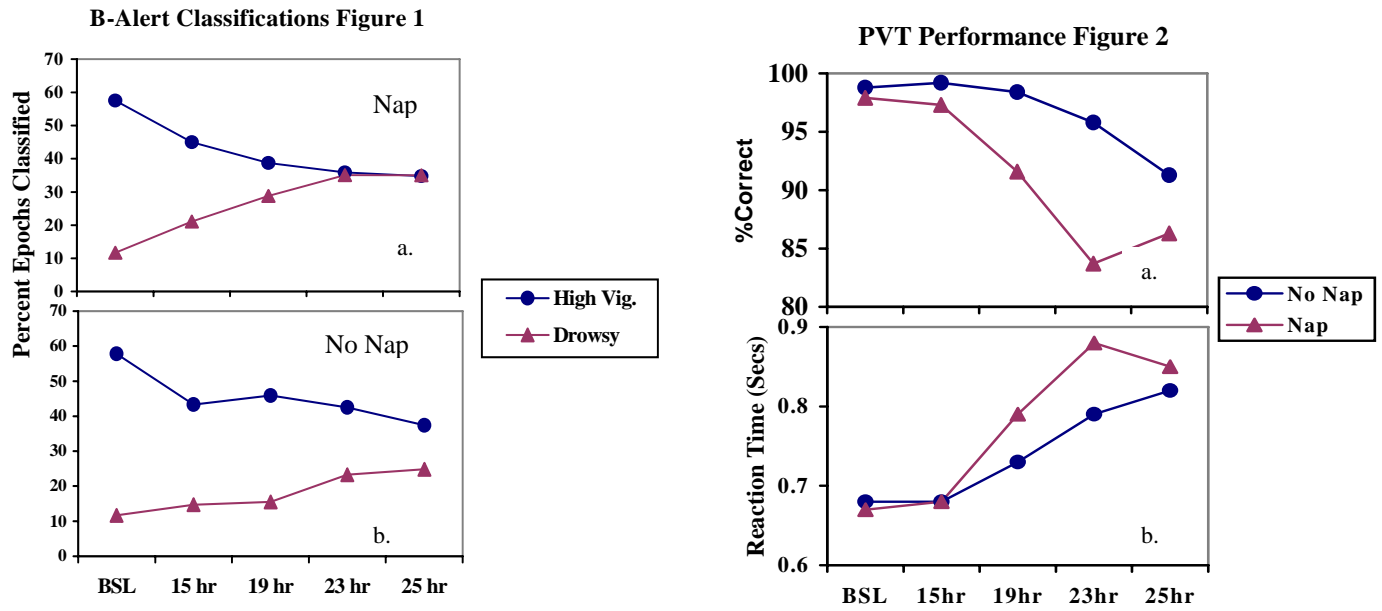


Figure 1. Percent epochs classified as high vigilance vs. drowsy during 20-min PVT-ABM at fully-rested baseline and time-points subsequent to awakening from partial sleep deprivation for a. Nappers and b. No-Nappers. Figure 2. a. Mean reaction time for Nappers vs. No-Nappers. b. Mean percentage of correct responses for Nappers vs. No-Nappers.

*Conclusions:*

These results demonstrate the sensitivity of the B-Alert classifications and performance measures to identify groups who differ in their vulnerability to the effects of sleep deprivation. These results support the B-Alert system's sensitivity to fatigue and suggest that the system could be applied in real-time to recommend the optimal time for a strategic nap.

*References:*

1) Makeig S, Jung T: Changes in alertness are a principal component of variance in the EEG spectrum. *NeuroReport*,7,213-216,1995.

This research was supported by NIH NINDS grant number R43-NS35387 and contract number N43-NS72367.

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