Detecting Drowsiness in RSVP Keyboard ™ BCI Users with SSPI

Tabatha Memmott*, Betts Peters*, Deniz Erdogmus+, Melanie Fried-Oken* & Barry Oken*

*Oregon Health and Science University, Portland, OR +Northeastern University, Boston, MA

Introduction

EEG measures of vigilance have been studied in fields concerned with driver and pilot alertness, as well as for effect on performance during cognitive tasks [1,2]. Given the importance of alertness and motivation on the P300, it follows that detection of reduced vigilance or drowsiness is critical to ensure maximal response. The necessity of integrating these fields becomes most evident in populations such as those with severe speech and physical impairments (SSPI), where individuals may not be able to communicate drowsiness or entirely control an alert-drowsy transition. This study looked at measures of drowsiness as a possible indication why participants might score poorly on these calibration sessions after eliminating the possibility of noise or other interference

Materials & Methods

Four participants with SSPI were selected from studies on the RSVP Keyboard™ BCI. Selection was based on those participants with sessions containing both good and poor performance (as measured by area under the curve [AUC] for calibration sessions). Participants self-rated for drowsiness on the Stanford Sleepiness Scale (SSS) [4]. EEG was recorded at 256Hz using a 16 channel g.tec system with standard 10-20 coordinates. Drowsiness detection was done using power measurements in the theta (4-8Hz) and alpha (8-13Hz) bands (using channels Fz, Cz, P1, and P2), and persistence of eye-blinks (using an average of Fp1 and Fp2). Initial power estimates for later comparison were calculated prior to presentation of stimuli, and epochs following this were screened for a 30% increase in both frequency bands, as well as a 50% increase in these bands' contribution to total power (power in band/total power). The epochs were formed by dividing the dataset into 4 second intervals, applying FFT, and calculating band power using MATLAB (v. 2015b).

Results

The power and eye-blink calculations were used to determine levels of drowsiness, outputting a score ranging from 0 [not drowsy] - 4 [very drowsy] based on the percent of epochs that satisfied the drowsiness conditions. A score of 1 would indicate 30-45%, whereas a score of 4 would indicate 75-100% of epochs satisfied drowsiness thresholds. The drowsiness detection score was more sensitive to individual participant performance differences in AUC than the SSS (see Table 1).

Table 1:

Participant	*Best Performance*			*Worst Performance*		
	AUC	*Drowsiness Estimate*	*SSS*	*AUC*	*Drowsiness Estimate*	*SSS*
I.	0.8311	0	1	0.6845	0.5	1
II.	0.9591	0	5	0.8032	2	1
III.	0.8168	0.5	1	0.5354	1	3
IV.	0.6418	0.5	2	0.5925	2	2

Discussion

Using the described approach to the detection of drowsiness, we demonstrated possible drowsiness implications on performance in a P300 based BCI system. Further studies should incorporate lateralized eye movements, utilize additional frequency information, and optimize channels for calculation of power measurements to make a more sensitive and accurate detector. While neither score can be directly related to performance (AUC) in this small sample, automated drowsiness detection is more practical for BCI in this or any population, and further developments will likely result in improved sensitivity for individuals.

The significance of this exploratory study is in creating potential avenues to improve performance on P300 based BCI systems by considering the impact of drowsiness on the underlying event-related potentials.

References: [1] Koshino, Y., et al. "The influence of light drowsiness on the latency and amplitude of P300." Clinical EEG and Neurosci. 24.3 (1993): 110-113 [2] Oken BS, Salinsky MC, Elsas SM. Vigilance, alertness, or sustained attention: Physiological basis and measurement. Clinical Neurophysiology 2006, 117:1885-1901. [3] Orhan, Umut, et al. "RSVP keyboard: An EEG based typing interface." Acoustics, Speech and Signal Processing (ICASSP), 2012 IEEE International Conference on. IEEE, 2012. [4] Hoddes, E., et al. "Quantification of sleepiness: a new approach." Psychophysiology 10.4 (1973): 431-436.

Acknowledgements: Support from NIH DC009834, CNS-1136027, IIS-1149570, CNS-1544895, NIDRR H133E140026.

OHSU