Stimulus Presentation Manipulations in P300-BCI: Improving Comfort Without Compromising Performance

S Mesa-G, NA Gates, EW Sellers

East Tennessee State University

East Tennessee State University Brain-Computer Interface Laboratory — We type with our brains, not our hands

L – 2

The 4th International BCI Meeting
Asilomar, CA, USA
May 31 – June 4, 2010

INTRODUCTION

A P300-based brain-computer interface (BCI) speller is a viable method of communication, but further improvements to existing paradigms may aid their transition from the lab to the home environment. P300-spellers traditionally use flashing stimuli (intensifications), which could produce eye fatigue if used over long periods of time. Since emitted, or absent, stimuli have also been shown to elicit a P300 response[1], we tested whether target omissions could meet or exceed the standard flash performance. The current study compared static gray-to-white flashes (flash condition; FL) to static gray-to-black on a black background (blink condition; BL) using the checkerboard paradigm[2] .

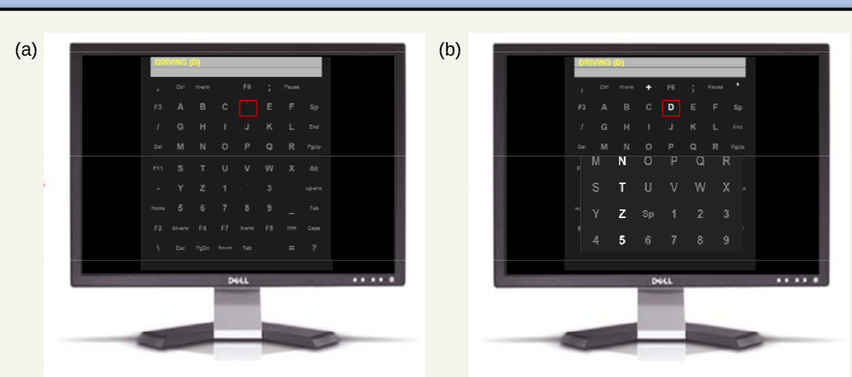


Figure 1. (a) Blink paradigm, gray to black on black background. (b) Flash paradigm, gray to white.

METHODS

Subjects: 16 healthy (9 female) students (mean age = 23.6, range = 19-39) were recruited from the ETSU psychology subject pool.
Paradigm: *Phase 1* – Using and 8x9 matrix, 36 items were presented in copy-spelling mode without feedback (SOA = 125 ms, 62.5 ms stimulus presentation). These data were used to derive a SWLDA classifier using an 800ms post-stimulus window. Written Symbol Rate[3] (WSR) was used to optimize the number of stimuli for each subject and condition.
Phase 2 – Online copy-spelling with optimized weights and online feedback.
Follow-up study – Subjects (2 to date) complete a ~2.5 hour online testing session (5 sentences of 96 items in BL and FL, counter-balanced) and reported eye fatigue pre- and post-session using a Visual Analog Pain Scale (VAPS; range 1 – 10).
Data Acquisition: 32-channel EEG was recorded (right mastoid reference left mastoid ground) at 256 Hz and bandpass filtered (range = 0.05 to 30 Hz).

WAVEFORM ANALYSIS

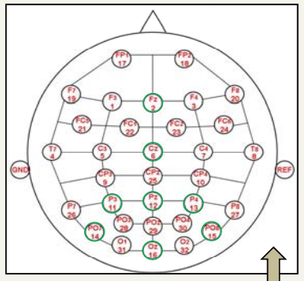


Figure 2. 32-Channel Montage. Channels circled in green were used for SWLDA input.

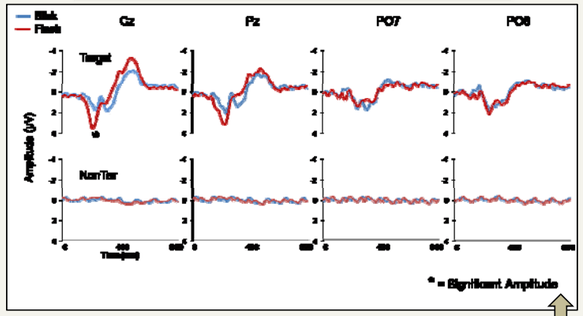
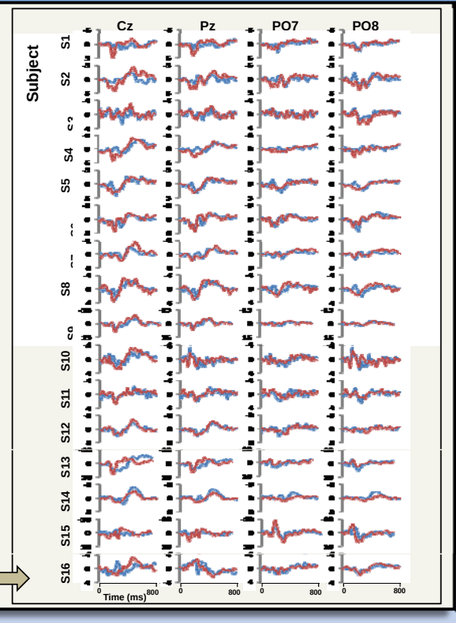


Figure 3. Grand Mean Waveforms. Responses for BL and FL targets (top) had comparable morphology with a significant amplitude difference at Cz. Nontargets for BL and FL were comparable (bottom).

Figure 4.Individual Waveforms. Averaged Blink and Flash target waveforms from calibration items (360 target flashes/3960 Nontarget flashes).



PERFORMANCE MEASURES

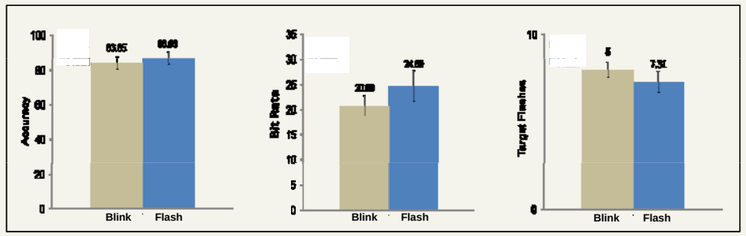


Figure 5. FL and BL conditions did not statistically differ for any performance measure (accuracy, bit rate, and number of target flashes).

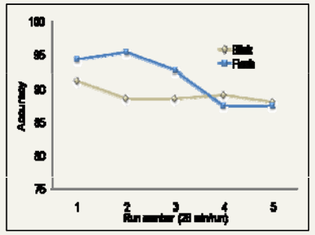


Figure 6. Preliminary results from the follow-up study suggest that FL mean accuracy is comparable to BL (91.47% and 89.07%). However, BL mean accuracy is more stable over time than FL accuracy, dropping only 3% versus 7% over the course of all 480 item selections. More data is being collected.

CONCLUSIONS

- Although BL has a reduced amplitude, importantly, performance measures are statistically similar.
- Preliminary results from the long sessions suggest BL accuracy is more stable than FL accuracy over prolonged periods of time.
- VAPS data indicate less eye fatigue in BL and improves ease of use without decreasing performance over long periods.
- Other paradigm manipulations will likely increase BL performance over FL across all time points.

REFERENCES

1. Ruchkin, D. S., Sutton, S., & Tueting, P. (1975). Emitted and evoked P300 potentials and variation in stimulus probability. *Psychophysiology, 12*(5), 591-595.
2. Townsend, G., Lapallo, B. K., Boulay, C. B., Krusienski, D. J., Frye, G. E., Hauser, C. K., et al. (2010) A novel P300-based brain-computer interface stimulus presentation paradigm: Moving beyond rows and columns. *Clin Neurophysiol*.
3. Furdea, A., Halder, S., Krusienski, D. J., Bross, D., Nijboer, F., Birbaumer, N., et al. (2009) An auditory oddball (P300) spelling system for brain-computer interfaces. *Psychophysiology, 46*(3), 617-625.

ACKNOWLEDGEMENTS

NIH/NIBIB & NINDS (EB00856); NIH/NIDCD (R21 DC010470-01)