# Suppressing Surrounding Characters During Calibration May Improve P300-Based BCI Performance

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We type with our brains, not our hands

## INTRODUCTION

The checkerboard (CB) paradigm decreases noise elicited by adjacent, vertical or horizontal, nontarget items that flash simultaneously with the target (or near the target when it is not flashing) and improves classification of the P300 response, thus increasing speed and accuracy of the P300 BCI speller[1]. The present study prevents all items surrounding the target item from flashing during calibration (suppression paradigm; SP). SP is expected to improve online performance.

(a) (b)

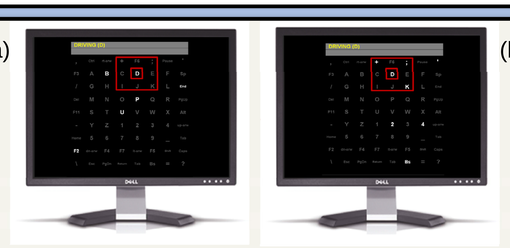


**Figure 1.** (a) SP, no contiguous characters flashing with target. (b) CB, adjacent diagonals flashing with target

## METHODS

**Subjects:** To date,13 (8 female) healthy students (mean age = 24.6, age range = 20 - 49) recruited from ETSU psychology subject pool.
**Paradigm:** Phase 1 - Each subject completed two sessions, one using suppressed items during calibration and one using standard CB mode (counter-balanced). 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 800 ms post-stimulus window. Written symbol rate[2] (WSR) optimized the number of target item presentations for each subject and condition.
Phase 2 - Online copy-spelling with optimized weights and online feedback using the standard CB.
Follow-up study - 7 subjects (to date), calibration is identical to the current study; however WSR was not used to optimize the number of stimulus presentations during the copy spelling.
**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

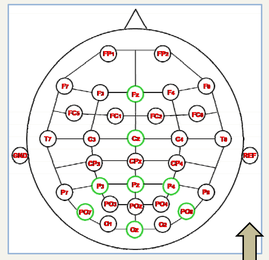
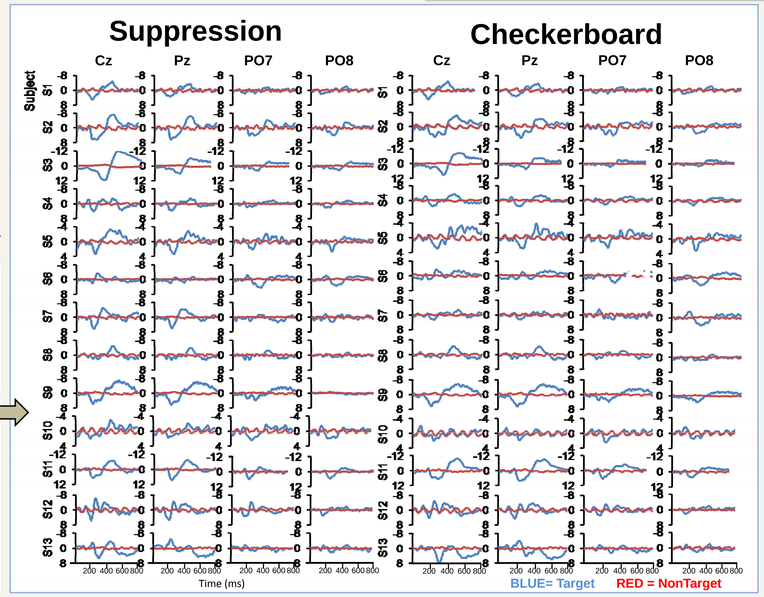


**Figure 2. 32-Channel Montage**. Channels circled in green were used for SWLDA input.

**Figure 3. Individual Target and Nontarget waveforms for Both Conditions.** Data from calibration items (360 target / 3960 Nontarget flashes).



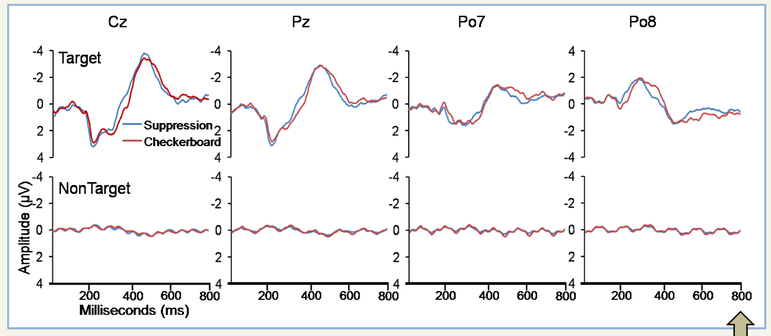




**Figure 4. Grand Mean Waveforms** for all 13 subjects in SP (red) and CB (blue) conditions for target (top) and non-target (bottom) items across the first five calibration runs (360 targets/ 3960 Nontarget flashes).

## Suppression Study Performance

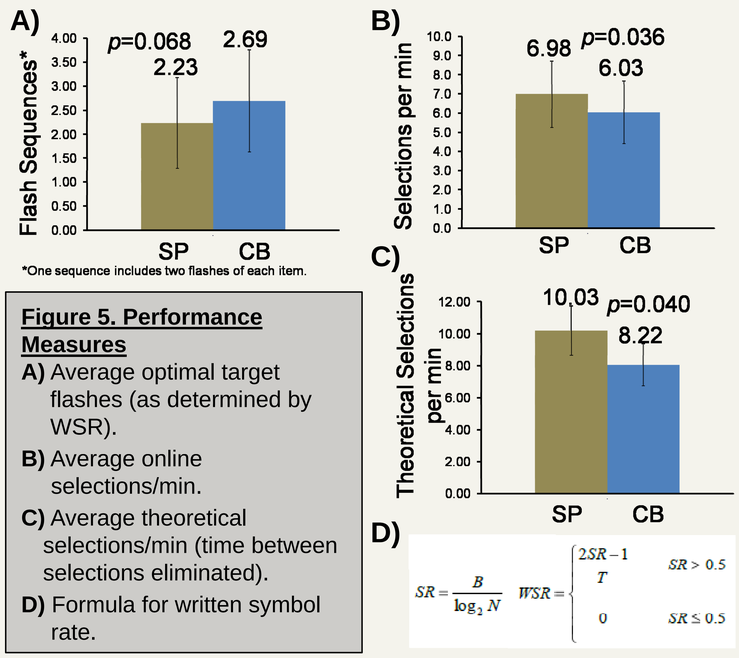



**Figure 5. Performance Measures**
**A)** Average optimal target flashes (as determined by WSR).
**B)** Average online selections/min.
**C)** Average theoretical selections/min (time between selections eliminated).
**D)** Formula for written symbol rate.

## Follow-Up Study

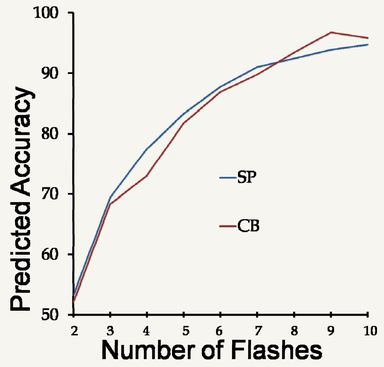



**Figure 6.** Offline analysis of predicted accuracy after each flash (2-10) averaged for all 7 subjects by condition. These data suggests SP classification may be higher than CB from 3 - 7 flashes.

## CONCLUSIONS

1. In conjunction with the preliminary follow-up study, these data suggest that using SP to collect calibration data increases online selections per minute, and SP has higher offline theoretical accuracy per flash with fewer flashes.
2. SP may also result in a decrease in optimal number of flashes required online (currently $p$=0.068).
3. Accuracy was statistically similar (SP=86% and CB=91%), however it is important to note that SP accuracy was collected from copy spelling in the CB.
4. These results suggest that characterizing subjects in SP can increase online performance by reducing the number of flashes required and increasing selections per minute, resulting in faster performance in the online system.

## REFERENCES

1. 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*.
2. 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

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