8065V -Effects of Keyboard Display on Word Accuracy for a Commercial EEG Speller: A Brainwave Analysis

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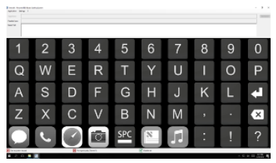
Introduction

P300 Brain Computer Interface （BCI） Speller

Keyboard Pattern


Intendix


B&W Smartphone

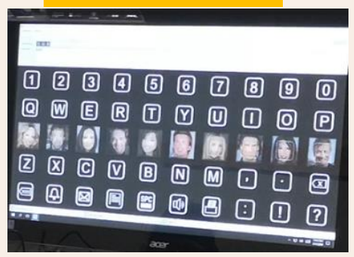

Pure Letter


Color Smartphone

Flash Pattern


Face Paradigm

Flash Paradigm


Row-Column Paradigm (RCP)

Example: Keyboard effect (Fernández-Rodríguez, et al., 2019)

Fatigue Effect During Experiment: Crucial for Augmentative and Alternative Communication (AAC)

Example: Fatigue effect (Brumberg, et al., 2018)

Background

Brain-Computer Interface (BCI) technology has potential to serve as a written communication tool for people with complete paralysis as a result of either a brain stem lesion (e.g., Locked-in Syndrome) or a progressive neurological condition (e.g., Amyotrophic Lateral Sclerosis) (Brumberg et al., 2018). These individuals have no means of producing speech, limb, or facial movements and are candidates for technology that captures and decodes neural signals. The P300 speller is one such technology that has been tested with typical individuals and with individuals with no functional speech because of a brain injury.

Research Questions

(1) Is there a significant difference (P<.05) between keyboard patterns for single letters?
(2) Is there a significant keyboard display effect on accuracy during the word spelling task? (p<0.05)

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Methods

Participants

- N=21, typical adults

Age range: 18-34, *M*= 25.73, *std.*= 5.41； Gender ratio (M:F)= 7:14； Native English speaker: non-native= 7:14

Procedure

- Word-spelling task
- Four different keyboard display patterns
- Randomized keyboard order
- Eighty letters (5-letter word x 4 within- x 4 between-keyboard)
- Duration: 2.5 hrs
- Fatigue effect detected

Data acquisition and signal processing

- Electrodes: Fz, Cz, Pz, Oz, P3, P4, PO7, PO8
- Butterworth bandpass filter [0.5 30] 6th order
- Epoch size [0.1 1]

Linear Discriminant Analysis (LDA)

Training: The first 5 letters of each keyboard pattern

Testing: 15 letters of the each keyboard pattern

Logistic Regression

Dependent variable:
- letter accuracy (0, 1)

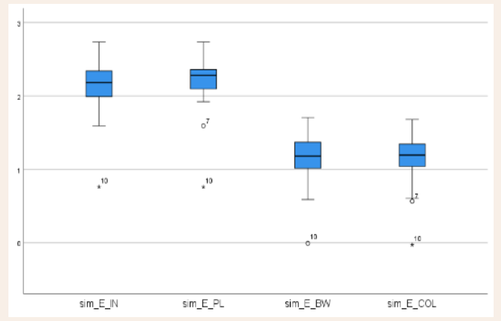
Predictors:
- Entropy difference of target letter during a flash (Entropy_Diff)
- Luminance difference of the target letter during a flash (Luminance_Diff)
- Entropy difference of the target face and its surrounding items (Sim_E_flash)
- Luminance difference of the target face and its surrounding items (Sim_L_flash)
- Age
- Native English speaker or not
- Word concrete rating score for the word that the letter belongs to
- Letter order

Method: Enter

Results

One-way ANOVA showed no significant differences across LDA classification accuracy for keyboard patterns.

		TESTING			
		IN	PL	BW	COL
TRAINING	IN	0.78	0.78	0.78	0.77
	PL	0.74	0.78	0.69	0.69
	BW	0.70	0.67	0.75	0.72
	COL	0.77	0.78	0.78	0.79



Sim_E_Flash
Entropy difference between the target face and its surrounding items

The keyboard format effect is detected using the logistic regression:
letter order***(p<0.05),
Entropy_diff, Sim_E_flash**(p<0.05),
Luminance_Diff, Sim_L_flash, Culture_English*(p<0.05),
Concrete_mean, age*(p<0.05)

Conclusion

In conclusion, the study (1) confirmed the fatigue effect using a self-constructed LDA model; (2) suggested a novel metric to discover the keyboard pattern effect for P300 BCI speller data with fatigue.

Selected Reference

1. Fernández-Rodríguez, Á., Velasco-Álvarez, F., Medina-Julia, M. T., & Ron-Angevin, R. (2019). Evaluation of flashing stimuli shape and colour heterogeneity using a P300 brain-computer interface speller. *Neuroscience Letters*, *709*, 134385.
2. Brumberg, J. S., Pitt, K. M., Mantie-Kozlowski, A., & Burnison, J. D. (2018). Brain–computer interfaces for augmentative and alternative communication: A tutorial. *American journal of speech-language pathology*, *27*(1), 1-12.

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