Selection Strategies for the RSVP Keyboard™ BCI: Different Strokes for Different Folks

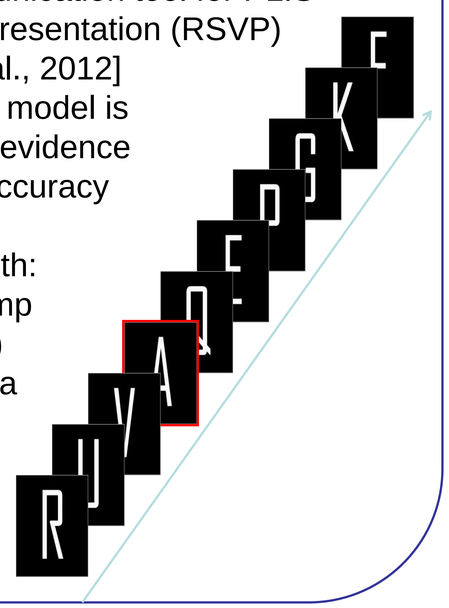
B. Peters, G. Bieker, A. Mooney, B. Oken, M. Fried-Oken
[1]*Oregon Health & Science University, Portland, OR, USA,*

INTRODUCTION

- We present the selection strategies tried and preferred by people with locked-in syndrome (PLIS) and non-disabled controls when using the RSVP Keyboard™ P300-based brain-computer interface.
- 8 PLIS and 18 non-disabled controls completed calibration sessions on the RSVP Keyboard™ using the mental imagery-based selection strategy of their choice.
- Most people chose to rely on speech imagery, with motor imagery second, and sensory, visual or combined imagery used by one person each.
- PLIS avoided using motor imagery-based strategies.

RSVP KEYBOARD™

- Non-invasive, P300-based BCI system designed as a typing & communication tool for PLIS
- Rapid serial visual presentation (RSVP) of stimuli [Orhan et al., 2012]
- Integrated language model is combined with EEG evidence to support spelling accuracy [Orhan et al., 2011]
- Signal acquisition with: 16-channel g.USBamp (g.tec, Graz, Austria)
- Active electrodes in a cap at approximate 10-20 locations, reference at TP10, ground at FpZ



PARTICIPANTS

- 8 PLIS (1 classical, 7 incomplete)
  - Diagnoses: ALS, brainstem stroke, Duchenne muscular dystrophy, cerebral palsy, and spinocerebellar ataxia
  - Participants with incomplete LIS include people unsuccessful with oral speech or writing due to severe speech and physical impairments
- 18 non-disabled controls

METHODS

- Each participant completed one or more calibration/EEG classifier generation sessions
  - Calibration included 50 or 75 sequences of characters
  - Sequences began with a target symbol, followed by a fixation cross and then a series of 10 symbols
  - Participants watched for the target symbol to reappear in the series of 10 symbols
- Instructions: ***"Do something to change your brain activity when the target appears."***
- Researchers provided examples of selection strategies based on motor, speech, visual, sensory, and auditory imagery.
- Participants were encouraged to choose a strategy that felt natural or easy to use.
- For each calibration session, participants could choose to continue using the same strategy, or to try something different. They were instructed not to switch strategies mid-session.
- Researchers recorded the specific strategies tried during calibration sessions and the final strategy used during the copy spelling task.
- Classifier accuracy was estimated from the area under the curve (AUC) of true positive vs. false positive rate for target vs. non-target classification.

RESULTS

- 3 PLIS and 7 controls tried 2+ types of strategies.
- 16 participants were satisfied with their initial strategy.
- 2 PLIS and 1 control showed no clear preference for any type of strategy.
- No PLIS used motor imagery alone. 2 PLIS tried a combination of motor and speech imagery, but neither preferred the combo strategy.
- Median tests on AUC scores for all calibrations completed by PLIS, X^2 (3, N = 43) = 4.21, p = .240, and control participants, X^2 (3, N = 44) = 1.87, p = .601, indicate that selection strategy had no significant effect on classification accuracy for either participant group.

Selection strategies tried and preferred by PLIS and control participants

Imagery Category	*PLIS (N = 8) Tried*	*PLIS (N = 8) Pref.*	*Cont. (N = 18) Tried*	*Cont. (N = 18) Pref.*	*Examples*
Speech	8	6	17	11	Imagine saying or screaming symbol name Imagine saying "Bam!" or "Yeah!" or similar exclamation
Visual	1	0	2	1	Imagine a line or slash through target symbol Visualize a pleasant image
Sensory	1	0	0	0	Imagine being pinched on the arm
Motor	0	0	6	4	Imagine punching or grabbing target symbol Imagine swinging a golf club
Combination	2	0	1	1	Imagine saying "There!" and moving right index finger Imagine saying symbol name and clicking a mouse

IMPLICATIONS

- Speech imagery was most popular for both groups.
- Motor imagery was 2nd most popular for controls.
- No PLIS used a purely motor imagery strategy.
- People with congenital motor impairments may lack experience with movements they are asked to imagine; PLIS may begin to find motor imagery difficult or unnatural. Strategies which can work well for users without disabilities, such as motor imagery, might not be ideal for some PLIS.
- Future research needed to optimize BCI performance, particularly for users with LIS, since selection strategies may improve attention or be associated with EEG changes.

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Correspondence: friedm@ohsu.edu

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