

Toward improved covert attention application using shifting stimuli

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Introduction: Most of P300-based brain-computer interface (BCI) spellers primarily use matrix layouts. These spellers are of limited application value for paralyzed patients with severe oculomotor impairments [1]. Recently, a gaze-independent BCI speller was proposed using rapid serial visual presentation (RSVP) [2], one limitation of which is that it is difficult to recognize targets due to the rapid presentation of characters. The fundamental objective of this study was to increase the perceptibility of target characters by introducing motion stimuli presented inside foveal vision, thereby fundamentally enhancing the performance of a RSVP speller.

Material, Methods and Results: We developed two event-related potential (ERP)-based BCI spellers using RSVP with motion and non-motion stimuli, respectively. Figure 1(a) illustrates an example of the sequence of motion RSVP (mRSVP), where all of 36 characters randomly presented for 133 ms (stimulus onset asynchrony) and moved into one of the six directions (2, 4, 6, 8, 10, and 12 o'clock). We evaluated the effect of the two different stimulation conditions on ERPs and its performance with seven able-bodied subjects. Figure 1(b) depicts grand-average ERPs for two representative channels (CPz and PO7) and topographical maps for standard RSVP (sRSVP) and mRSVP across all subjects. Both stimulation methods show typical P300 responses for targets, but their averaged maximum peak amplitudes are higher and latencies are shorter for mRSVP than sRSVP (latency: 562 ± 68 ms for sRSVP vs. 482 ± 34 ms for mRSVP; peak amplitude: 4.38 ± 2.0 μ V for sRSVP vs. 5.0 ± 2.8 μ V for mRSVP). The P300 could be affected by stimulus evaluation and response production. The mean classification performances of sRSVP and mRSVP spellers were $84.1 \pm 10.5\%$ and $90.5 \pm 7.1\%$ (chance level: 2.77 %), respectively.

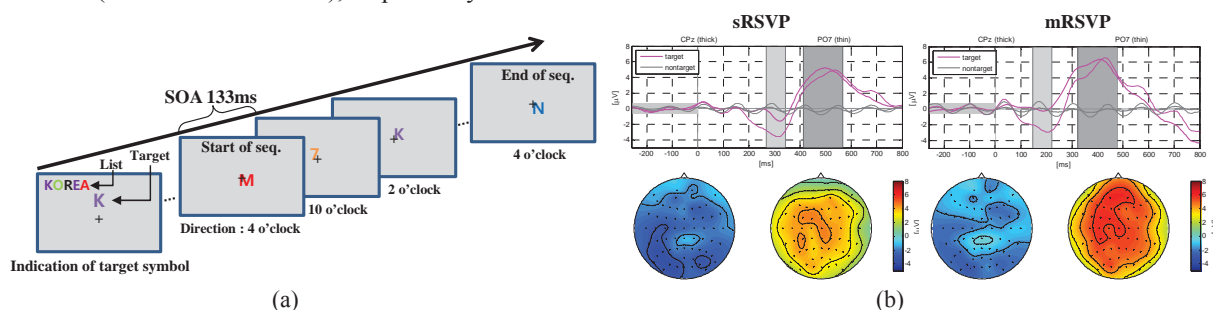


Figure 1. (a) Motion RSVP paradigm. (b) Grand average ERPs for targets (magenta) and non-targets (gray) at CPz and PO7 (upper panel), respectively, and topographical ERP maps in the two selected time intervals (lower panel).

Discussion: The mRSVP method showed not only stronger ERP responses but also shorter latency than the sRSVP, from which it can be thought that motion stimuli could be more easily recognized than static ones from the neurophysiological point of view. In this study, moving directions of visual stimuli were randomly designated for mRSVP. We will design and test another mRSVP method in which a motion direction is pre-defined and fixed during visual stimulation.

Significance: Our results revealed that the performance of a conventional RSVP speller can be improved by combining dynamic motion to the conventional stimulation method, demonstrating the feasibility of the mRSVP stimulation method.

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References

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