 DOI: 10.3217/978-3-85125-962-9-216

Event-Related Potential to visual cues in Motor Imagery Brain-Computer Interface

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Introduction: In general, visual cues (like arrow or text) are used to instruct a subject the direction of imagery in offline data collection of motor imagery (MI) Brain-Computer Interface (BCI), while these stimuli may not be used in online MI-BCI. Such visual stimulation may introduce Event-Related Potential (ERP) in offline data, causing the difference in offline from online data. However, the existence of ERPs is not been thoroughly studied. In this study, we investigated ERPs in public motor imagery datasets.

Material, Methods and Results: We analyzed three public datasets on left- and right-hand MI to confirm the ERPs: Lee(2019) (n=54) [1], Cho(2017) (n=52) [2] and Shin(2016) (n=29) [3]. The data name is the author's last name and the publication year of the paper. Lee(2019) measured the same subject twice on different days, so the session was divided and confirmed. For direction instruction to subjects, arrows were used in Shin(2016) and Lee(2019) while text was used in Cho(2017). In Shin(2016), the subjects started imagery at the appearance of the fixation cross that is 2 sec. after the delivery of the instruction cue. For ERP analysis, we conducted preprocessing as a common average reference, filtering (0.5 to 10 Hz), baseline correction, and epoching at -2 to 2 sec. based on MI onset.

Figure 1 represents the grand average of ERPs over all subjects on the C4 channel for each dataset. At the time when the instruction cue appeared, it can be seen that the amplitude of the left MI was higher than that of the right MI in the C4 (Shin(2016): 1.75/0.43 (left/right), Lee_{s2}(2019): 1.02/0.53, Cho: 1.76/0.65), and the opposite patterns were found in the C3 (Shine: 0.98/1.32, Lee_{s2}: 0.79/1.02, Cho: 1.47/1.71). In addition, the ERP peaks look faster and steeper in arrow stimuli (Shin(2016) and Lee(2019)) than in letter stimuli (Cho(2017)).

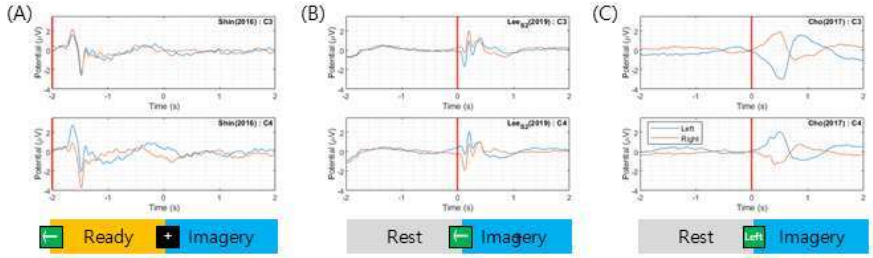

Figure 1. *Event-related potentials of motor imagery on C4 (Lee(2019) and Cho(2017)) or FCC4h (Shine(2016)) electrode. The red line shows the instruction cue, and the 0 of x-axis represents the motor imagery onset.*

Discussion: We found the contralateral strong ERP in the three MI datasets. Interestingly, such ERP presents after the instruction cue, not after MI onset (0 sec.) in Shin(2016). From this, we can infer that the ERPs may be less associated with imagination but may reflect cognitive processing. Indeed, we also observed the different temporal patterns of ERP between arrow and text. Additional work on more data and new experiments may help in drawing solid conclusions.

Significance: In previous MI studies, there was no consideration of the low frequency band (ERP), but in the MI paradigm, there are differences depending on the direction.

Acknowledgements: This work was supported in part by the National Research Foundation of Korea (NRF) under Grant 2021R1I1A3060828, and in part by the Institute of Information and Communications Technology Planning and Evaluation (IITP) funded by the Korea government under Grant 2017-0-00451.

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