Cortical correlates of a priming-based learning enhancement task: a Brain Computer Interface study.

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Priming is an automatic cognitive mechanism according to which the exposition to a certain kind of stimulus can modify the response to a subsequent stimulus. Even if literature has widely dealt with this phenomenon, experiments that analyses effects of priming in learning and their neural correlates are still few. The main aim of this project is to evaluate whether semantic priming could be considered as a useful method to improve the performances of subjects involved in a learning task. In particular, we expected that the subjects, which received semantic priming, would show faster behavioral patterns and that the priming effect would result in a lower cognitive load correlated to a lower engagement of anterior cortical areas. We then hypothesized that during tasks primed by semantic-related cues beta and gamma frequency bands will show a lower activation with respect to non-primed ones. Thirty right-handed volunteers (age range 18-26) with normal or corrected to normal visual acuity and without neurological illness nor learning disabilities participated in the study. We designed an experiment with three groups (semantic prime; neutral prime; no prime) and three conditions (letter recognition, word recognition, word definition). A Neurosky Mindwave BCI device was used to collect frontal EEG data. The use of the open source OpenVibe stimulation software allowed us to implement a Python code to build the experiment. Significant differences were found in all conditions. In the first task (Letter recognition), the prime-group reported an average RT of 0.63 seconds while the other two groups (neutral-prime and no-prime) reacted slower (respectively, 0.92 s and the 0.85 s). In the second task (Word recognition), the prime-group RTs had an average of 0.44 seconds vs 0.84 and 0.81 of the other groups. In the third task (Definition), the prime-group answered took an average of 4.73 seconds to respond, versus 6.38 and 6.86 of other 2 groups. Finally, to analyze EEG correlates of behavioral results a Matlab's tool (EEGLab) was used to analyze the data recorded by the BCI. As expected, primed-subjects reported a less average activation of Beta and Gamma waves, immediately before and after the onset of the stimulus ($F(2,27) = 20.123$, $p < .001$; $F(2,27) = 20.002$, $p < .001$). Our EEG data showed in the frontal areas the priming effect is correlated to a reduced activity, showing a cognitive discharge. These data suggest that is possible to structure education material so to increase learning performance and/or reducing the cognitive load. These achievements are particularly wishful in case of learning disorders or when many information have to be learned in a brief time. The use of a BCI device might then be used to assess the cognitive load providing specific feedback when excessive, less-functional level of cortical activity is reached. We believe that a systematic use of BCI devices will foster the implementation of cognitive-driven education and enhancement programs.