 DOI: 10.3217/978-3-85125-467-9-175

Effect of a cognitive involving videogame on MI task

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Introduction: Researcher and developers have to face with performance variation in motor imagery[1] across and within subjects and its fluctuations over time. In addition MI achievement variations within subjects are closely correlated to neurophysiological variables[2]. In our study a MI task was submitted to a group of healthy subjects before and after playing BCIGEM videogame for 90 minutes. Some EEG features were found, suggesting a different pathway of activation inside MU rhythm during Motor Imagery (MI) after a mentally challenging activity like playing a videogame.

Material, Methods and Results: BCIGEM is a videogame derived from popular 'Gem swap' that includes some additional subroutines including a MI scheme. A 32 channel AgCl cap and a Neuroscan (Fs 500Hz, extracephalic reference) device was applied to acquire EEG data while subjects are playing pc version of BCIGEM videogame. Subjects performed calibration sessions and game session alone in a soundproof room under control of a video surveillance system. In a different day participants already performed a training procedure while on experiment day they received once more instructions about gaming. Each candidate (11 subjects, age range 22-27, all male right-handed) answered to a questionnaire before starting the game to collect self-reported motivation, tiredness and attention level. Analysis was focused on calibrations sessions before and after playing the game for 90mins. Subjects were instructed to imagine a brief hand movement (near 1s) according to an arrow's direction shown on screen in front of him (at 0s time, 10 MI right/10 MI left). Near 1s before arrow appearance a cross come out on center of screen to prepare the subject for the task. According to previous findings[3] ERD seems unaffected by movement durations and brief movement imagery has a larger impact on pre-movement mu ERD rather than continuous movement. For this reason analysis window was extended from -1s before arrow onset to 1s after its appearance. EEG was preprocessed to extract epochs (-3s to +5s from arrow appearance marker) and filter data (7-30Hz) with a two-way least-squares FIR. A preliminary screening on calibration data running a combination of CSP spatial filter for feature extraction and LDA as classifier was performed to include only participants able to perform MI task. During this offline procedure only who scored at least 70% of accuracy was included in the study (4 subjects was excluded). To analyze EEG features only the MU band (8-13Hz) was isolated from data and only C3 or C4 contralateral to movement was taken in consideration. Time interval between -3s to -1s before onset of movement (i.e. time 0s) of each epoch was considered as baseline and average power spectrum across subjects was calculated for each second. While before playing BCIGEM the motor imagery related mu-band power decrease is sustained along all interval -1s to +1s (-1s to 0s 45% of ERD, 55% in 0s to +1s) , after 90mins of BCIGEM playing the motor imagery ERD is concentrated in interval 0s to 1s (-1s to 0s 10% of ERD, 90% of ERD in 0s to +1s). In both situations at +2s EEG returned at the level reached in baseline. Focusing on 10-12Hz Mu band same phenomenon is described with an ERD ending at +2s in calibration data after playing BCIGEM, while before playing the game still a little ERD is present ($p<0.03$ L:-38% R:-66%).

A study on baseline power composition was performed: in 8-14Hz band on Cc electrode after playing the game a relative decrease of lower mu representation (8-10Hz) was found after playing BCIGEM(L:-22%,R:-13%). If frequencies include upper theta (6-8Hz), upper theta and lower mu decrease (T L:-15%, R:-11% lower MU L:-7.5%,R:-4%) in comparison to upper mu bands (10-12Hz and 12-14Hz) after playing BCIGEM. In fact dividing ERD in two sub-bands (8-11Hz and 11-14Hz), still ERD is less evident after playing BCIGEM in 8-11Hz ($p<0.035$, L:-30% R:-76%) band but an inverse behavior in 11-14Hz is present compared to results before playing BCIGEM ($p<0.05$). In 11-14Hz there is a power decrease more evident after playing the game (L: +28%, R: +14%) reflecting higher frequency representation found in baseline.

Discussion: Results presented show a different behavior inside mu band before and after 90mins of involvement in a mental activity. As presented different ERD architecture could influence the motor imagery performance during time. MI tasks suffer of limitations in performance caused by user-dependent factors[4] and this further change in SMR attenuation phenomenon could be relevant in contexts where mental fatigue is an additional element. As consequence a recalibration to adapt BCI algorithms to identify an ERD with different characteristics could be a solution to maintain a stable BCI performance.

Significance: BCI outcomes could benefit of understanding brain dynamics in mentally challenging situations.

Acknowledgements: This work was supported in part by the Army Research Laboratory under Cooperative Agreement N. W911NF-10-2-0022 and in part by Ministry of Education, Taiwan, under Grant N. 105W963.

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