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Influence of cognitive variables in a Brain-Computer Interface driven application

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Introduction:

Sensorimotor rhythms Brain-Computer Interfaces (SMR-BCIs) allow users to actively control a device with cortical, muscle independent, activity. This characteristic has drawn attention to possible uses within environments richer and more interactive than laboratories, in particular for unpaired people. Nevertheless rates of success in using BCI vary widely and, although it has been demonstrated that several cognitive variables might affect BCI performances [1], such a relationship has not been fully investigated in interactive BCI driven applications.

Participants and method:

Data were acquired from ten subjects (four female, average age 23.1 ± 2.9 years). Participants gave informed consent to the study and received no remuneration. They performed three recording sessions of a two-classes SMR-BCI [2]: in the first session (CALIBRATION condition) 4 offline runs with positive feedback were exploited to calibrate the system; the second session (ONLINE condition) was devoted to test the BCI online with a cue-based visual protocol (4 runs of 30 items each); finally, the third session involved the control of the BCI Race Game "Brainrunners" of the Cybathlon Rehearsal 2015 (http://www.cybathlon.com). The videogame consisted in making a virtual avatar avoid obstacles by delivering the correct BCI commands. In this session, subjects performed 3 runs without opponents (GAME-SOLO condition, 42 items) and 3 runs playing versus virtual opponents (GAME-GROUP condition, 42 items).

For the psychological data acquisition, we used the Questionnaire of Current Motivation BCI edition (QCM-BCI) to investigate motivation [3], The Positive and Negative Affect Schedule (PA and NA) to assess mood [4] and the Mini Locus of Control Scale [5].

Results and discussion:

Results show a significant decrease of the BCI accuracy in the GAME-GROUP condition versus the ONLINE condition ($p<0.01$). Performance in the ONLINE condition correlates positively with the PA scale ($r = 0.645$, $p<0.05$) and the QCM-BCI Mastery Confidence ($r=0.676$, $p<0.05$) and negatively with the NA scale ($r= –0.74$, $p<0.05$) and the QCM-BCI Fear of Incompetence scale ($r= –0.539$, $p<0.05$). Overall performance moderately correlates with Internal Locus of Control ($r=0.38$, $p<0.01$).

Results show how cognitive variables affect the performance during an SMR-BCI task. However no effect could be observed in the GAME condition, probably due to the difficulty of the task and the increasing number of visual stimuli that need to be processed. Although we cannot exclude that such psychological variables influence BCI accuracy, external and environment-related conditions (e.g. competitiveness, application complexity) may be predominant.

Condition		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Average
ONLINE	[%]	95.0	65.0	95.0	89.2	95.0	80.8	97.5	100.0	78.3	99.2	89.5 ± 11.35*
GAME-SOLO	[%]	83.3	50.0	42.9	59.5	100.0	73.8	90.5	100.0	78.6	92.9	77.1 ± 20.4
GAME-GROUP	[%]	85.7	42.9	28.6	52.4	100.0	61.9	100.0	100.0	90.5	92.9	75.5± 26.7*

Table 1. Percentage of correct commands delivered for each condition. Statistical significance has been found between ONLINE and GAME-GROUP conditions (* $p<0.01$).

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