On the correlation between Brain Computer Interface performance and chronotype

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Abstract—A novel way of using Brain Computer Interface (BCI) has emerged, which proposes to use these systems to monitor users mental states. In this work we would investigate if the users’ morning/evening activity preference could be related to BCI performances. Preliminary findings highlighted a correlation between chronotype and the latter.

Keywords—Chronotype, BCI, P300, Written Symbol Rate.

I. INTRODUCTION

A Brain Computer Interface (BCI) is a direct communication pathway between the brain and an external device in order to provide an alternative/additional communication channel to people suffering of severe motor impairments [1]. However recently there was a growing interest for different applications of this technology, such as monitoring of the user mental states (attentional level, workload, fatigue, etc) carrying information not sent intentionally by the user [2]. This information could be used e.g. in closed loop by the system itself to improve the interaction with the user. One of the most commonly feature used to control a BCI is the P300 event related potential (ERP). This component is also considered to be a measure of neuroelectric activity related to cognitive functions such as attention, allocation and information processing. In literature there are evidences on the influence of several psychophysiological factors on the P300 potentials, such as morning/evening activity preference (chronotype), time of day, fatigue and etc [3], [4]. This study aimed to investigate if this variability affects ERPs-based BCI performance by means of repeated BCI sessions in the same day.

II. MATERIAL AND METHODS

A. Experimental Protocol

Six healthy subjects were involved in this study (4 male, 2 female, mean age 25±2). All subjects had previous experience with ERPs based BCIs. Scalp electroencephalographic (EEG) signals were recorded (g.USBamp, gTec, Austria, 256Hz) from 8 positions (Fz, Cz, Pz, Oz, P3, P4, PO7 and PO8). Each channel was referenced to the right earlobe and grounded to the left mastoid. The stimulation interface consisted in the Farwell and Donchin’s Speller [5], a 6 by 6 matrix containing 36 alphanumeric characters. Each subject underwent 5 BCI recording sessions in the same day at well defined times: 10:00 AM, 12:00 AM, 2:00 PM, 4:00 PM and 6:00 PM. The first two sessions will be identified as morning sessions and the last two as evening sessions, while the performances achieved during the 2:00 PM session (noon session) are been reported, but not considered for the statistic analysis, since we chose to consider only the morning and evening sessions for the correlation with chronotype. A session consisted of 6 runs, composed by 6 trials each. A trial consisted in 8 random repetitions of the 12 stimulation classes on the interface (6 rows and 6 columns). All the 36 alphanumeric characters were presented as a Target once in each session. Before the 10:00 AM session subjects were required to fill the Morningness-Eveningness questionnaire (MEQ) [6] to assess chronotype as Morning, Evening or Neutral Type considering his preferences, behaviour and habits.

B. Performance analysis

EEG signal was reorganized in overlapping epochs lasting 800ms and following the onset of each stimulus. We used a Stepwise Linear Discriminant Analysis (SWLDA) to select the most relevant features that allowed to discriminate Target stimuli from No-Target ones [7]. In particular a 20 rounds cross-validation was carried out for each recording session using all possible combinations of three runs as training set and the remaining three as testing data set.

The Written Symbol Rate (WSR, symbols for minute) [8] was calculated for each iteration as a function of the number of stimuli repetitions in the trial. For each iteration we considered the maximum WSR value, which represents the best trade-off between accuracy and speed of selection (stimuli repetitions). We performed 6 one-way repeated measures ANOVA (CI = .95), using Session Type (Morning sessions-Evening sessions) as factor and the distributions of the maximum WSR values as dependent variables.

![Fig. 1. WSR values for morning, noon and evening sessions.](image-url)
III. RESULTS

Figure 1 shows WSR values for morning and evening sessions and the table 1 illustrates the results of the 6 one-way repeated measures ANOVA with the chronotype evaluated by means of the MEQ. WSR values were significantly different between morning and evening sessions for five subjects out of six. Subjects 1, 2 (Morning Type) and 4 (Evening Type) exhibited coherent WSR performance with their chronotype. Subject 3 did not show significant difference between morning and evening sessions, consistently with a Neutral Type (i.e. no preference between morning and evening). Subjects 5 and 6 also performed better in the morning; this result was not consistent with the subject’s rate of preference at the MEQ, since they were both Neutral Type.

IV. CONCLUSION

Online detection of user mental states during a BCI task, could be used e.g. in a closed loop to auto adapt itself to the user state in order to maximize performance. In this study we would to investigate if user chronotype could reflect on the BCI performance assessing the P300 Speller interface WSR across repeated session during the same day. However it should be stressed that performance using this interface does not depend only from the cognitive potentials (e.g. P300), but also by other contributions, such as the Visual Evoked Potentials (VEPs), which strongly depends on gazing the target [9]. Despite of this, it could be plausible that variations in performance depending on the chronotype could be related to variations in cognitive components which take part in the classification stage, such as P300 potentials. These preliminary findings (sample size 6 subjects) could suggest that user chronotype influences the ERPs-based BCI performances. In fact, for 4 of the 6 subjects performances resulted consistent with their chronotype, assessed by means of the MEQ. Despite Subjects 5 and 6 resulted Neutral Type from the MEQ, they exhibited significantly higher performance during the morning with respect to the evening. However, this could be related to other factors, such as the physical and/or mental fatigue induced using BCI system all the day. In this way, further investigation is currently performed as to confirm these preliminary observations on a larger sample of subjects and also to investigate the possible correlation of this variability with other psychophysiological factors, such as workload required, motivation, mental fatigue etc.

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REFERENCES


