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Competitive and Collaborative Multiuser BCI

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Introduction: In recent years, brain-computer interface (BCI) applications for gaming of healthy individuals have gained a considerable interest [1]. Multiuser BCI games are still rare and mostly limited to motor imagery as a control strategy [2]. Here we propose BCI games based on simple operant conditioning that can be used for gaming of healthy people or for therapeutic purposes [3]. We compare collaborative and competitive strategies in a group of healthy naïve BCI users.

Material, Methods and Results: Six naïve pairs of healthy volunteers (age 24±7) took part in the study. Their EEG was recorded with usbamp (Guger technologies, Austria), bipolarly between F3 and F4 (control BCI signal) and monopolarly at AF3,AF4,A3,A4,FC3,FC4,C3,Cz,C4,O3,Oz,P4,O1,O2 (post-hock analysis). A sampling frequency was 256sam/s, impedance below 5kΩ, ear reference, on-line filter 5-30 Hz. A moving average window of 0.5s was used to calculate EEG power in alpha (8-12 Hz) and beta (13-30 Hz) band and in 5-30 Hz band. A relative power was calculated as power(alpha or beta)/power(5-30 Hz) to eliminate between-subject differences in EEG amplitude. Participants sit in the front of a computer looking at the screen showing a simplified 'see-saw'. In a collaborative game their used the alpha band power (strategy: relaxation) to keep the see-saw in balance. When player's 1 power was within ±7.5% of player's 2 power for 1 s they scored one point. In a competitive game (strategy: concentration), when player's 1 beta power was >20% of player's 2 power for 1s, player 1 scored a point. After an initial training, players played 2 runs of collaborative and 2 of competitive games, each run lasting 200s. Signal processing was performed in Simulink/Matlab (Mathworks, USA) while Java was used for visualization. Figure 1a shows the alpha power of two players in a collaborative game and Fig 1b shows their beta power in a competitive game. Fig 1c presents scalp maps of alpha power during rest and a collaborative task, showing the shift of maximum activity from the occipital towards frontal regions during game. The average score for 6 pairs in a competitive task was for run1: winner 39±24 and looser 13±12; run 2: winner 49±19 and looser 16±14. In a collaborative task the score was 42±12 for run1 and 55±19 for run2. A score was slightly better in a collaborative than in a competitive task, either due to the nature of the task (relaxation vs concentration) or a strategy (collaboration vs competition).

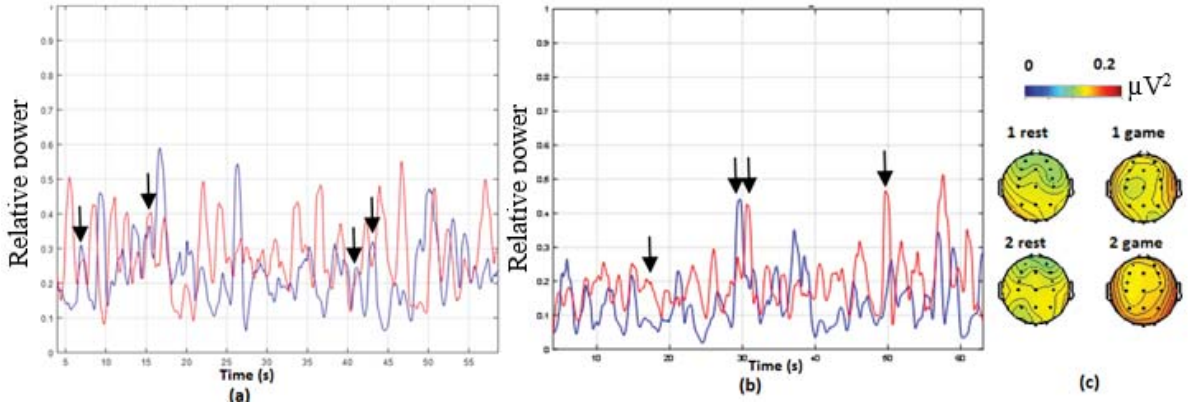

Figure 1. Relative alpha power of two players (red and blue color) during a colaborative task. b) Relative beta power dring a competitive task. Arrows show examples when points were scored. c)Scalp maps of alpha power in one couple, notice spatial shift of the maximum power towards the frontal region.

Discussion: The study shows that naïve participants can learn how to collaborate/compete using their brainwaves within one training session. Brain computer games can be used as inclusive gaming strategy for both able-bodied and heavily physically disabled. Group BCI games can also be used to enhance brain training strategies [3].

Significance: Collaborative/relaxation game strategies might be easier to learn than competitive. Voluntary modulation of brian activity from one cortical site causes wide spread changes that can be utilised for complex neuroodulation strategies but could also have a detrimental effect.

References

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