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Social inclusion as feature to improve BCI skill training: A feasibility case study in cerebral palsy

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Introduction: Operating brain-computer interfaces (BCIs) that are based on modulation of spontaneous electroencephalogram (EEG) rhythms is a skill that users have to learn. Training time varies significantly among users and it can take up to several months of time before minimum BCI control becomes possible. One reason for this may be the design of BCI training paradigms [1]. Trials of mental activity are collected prior to BCI use and used to calibrate BCI model parameters. During this initial data collection no feedback is provided to users. This is not very motivating and engaging for users. Recently, we introduced a thought-based one-switch row-column communication board for users with cerebral palsy [2]. To make BCI skill learning more motivating, we lately also introduced a jigsaw puzzle game-based training paradigm [3] that presents feedback from the very start. Initially sham feedback and once enough data is available for BCI calibration, online feedback. Moreover, the game was designed following user-centered design principles and explains the concept of BCI use and allows users to get familiar with the dynamics of BCI control. A pilot study in four users with cerebral palsy (CP) showed that the acceptance was high and users liked the game-based training approach [3]. Three out of the four users achieved performance better than chance level after about 30 minutes of training. Fig. 1 shows a user assembling a puzzle. Here, we propose social inclusion as another feature for improving BCI training. End users should not perform training alone but engage in direct competition with other persons.

Material, Methods and Results: One CP user participated in this single-case study. The user learned to operate the BCI-based one-switch row-column communication board by undergoing the jigsaw puzzle game-based training as described in [3]. After about 30 minutes of training, the CP user played three times the Tic-Tac-Toe game against his caregiver. Tic-Tac-Toe is a paper-and-pencil game for two players, "Lion" and "Elephant," who take turns marking the spaces in a grid composed of three rows and three columns. The player who succeeds in placing three respective marks in a horizontal, vertical, or diagonal row wins the game (Fig. 1). The game, implemented for Android OS tablet computers, accepts BCI input by using the one-switch row-column paradigm [2, 3] and by touch (caregiver). The results of the three games were a win, a loss and a tie.

Figure 1. *User training with the Puzzle game app (left). Graphical user interface of the Tic-Tac-Toe game (right). Modified from [4].*

Discussion: Investigation of BCI performance and game moves confirms that the user had control over the BCI and was able to place game characters in accordance with the game rules.

Significance: Enhancing BCI training and improving social inclusion is crucial for CP users. The proposed approach combines both issues successfully.

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