Table Tennis with BCI

Is it possible to play a simple table-tennis computer game just through „the power of thoughts"?

Yes, it is. The EEG-based Brain-Computer Interface (BCI) technology developed fast over the past decade (Pfurtscheller and Neuper, Proc. IEEE 2001). New algorithms were implemented and the field of clinical applications enlarged. The Graz-BCI detects and classifies mentally induced changes of patterns in oscillatory brain-electrical activity online and in real-time.

The input signal of the BCI is the EEG recorded with electrodes placed on the scalp. Usually, the user performs different types of motor imagery tasks like, for example, imagination of right or left hand movements to obtain control over the BCI system. In a number of training sessions the computer learns to recognize and classify subject-specific EEG patterns related to the motor imagery task. When a classifier is realized the real-time feedback session begins. In the most simple case a horizontal bar on a computer monitor has to be moved to the right or to the left. If the user is successful with his/her strategy and EEG-patterns change in the required way by motor imagery, the feedback bar will deflect to the intended side. This kind of feedback was found to be very helpful for the BCI-user to generate a reliable control signal.

Important is the feedback strategy, which should be highly motivating for the user, on the one hand, and variable in the aspect of speed on the other hand. Therefore, simple computer game-like paradigms were developed and tested with able-bodied subjects and patients. One example of a new training-paradigm is the „table tennis-game", at which the racket position on a computer monitor is controlled via the BCI-system. Depending on the performance of the subject the speed and the breadth of the racket can be adapted. Either one subject plays against the computer or two users can play together (see Fig. 1).

Practical usability of an EEG-based BCI is given, if the user reaches classification error rates of 10 % or lower. Most subjects or patients need a training period of some days up to months to fulfill this criterion. In a recent study on paraplegic patients the so-called „basket paradigm" was used to investigate the relationship between speed (i.e. trial length) and information transfer rate. After some initial training sessions the patients had to hit a marked „basket" at the bottom of the screen with a down-falling „ball". The falling time (i.e. the time the ball takes to cross the screen) was varied by the investigator and the horizontal position of the ball is directly controlled in real-time by the BCI output signal. The study revealed highest possible information transfer rates (up to 17 bit/min) for trial lengths of 1.5 to 2.5 seconds. Due to a fixed pause of 1 second between trials subjects had only 0.5 to 1.5 seconds of feedback to hit the target. (Krausz, G. et al. Applied Psychophysiology and Biofeedback, (2003) in press). An information rate of e.g. 17 bit/min for the table tennis game means that about all 4 seconds the „racket" can be moved to the right or left.

To realize an EEG-controlled table tennis game, it is first necessary that every partner underwent some BCI-trainings sessions, e.g. with the „basket paradigm" to obtain a real-time control of the BCI output signal. Thereafter, when the classificatory error is reduced to around 10% in each subject, both partners can be connected via the same biosignal amplifier system (see Fig. 1) with the laptop and the table tennis can start.

The main goal of „table tennis" or „basket game" is to train patients with severe neuromuscular disorders such as amyotrophic lateral sclerosis (ALS), brain stem stroke and spinal cord injury as effective and fast as possible to operate a BCI system. BCI technology can allow people, who are completely paralyzed, to communicate with care givers, use word spelling programs (virtual keyboards) or operate neuroprothesis and robotic prothesis.

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