EEG-based control of functional electrical stimulation (FES) for grasp restoration

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Aim of this study was to combine a BCI with a FES application. A tetraplegic patient (28 years, traumatic spinal cord injury 04/1998, incomplete below C4, complete below C5) with the loss of volitional activation of hand and finger muscles has participated in this study. Since 1999 BCI training with different motor imagery has been started. After some month of training the patient was able to control a mechanical orthosis with the BCI. An interesting result of this training was a mid-central focused beta oscillation with a frequency of about 17 Hz. These oscillations can be induced to date, though the training was rare in during last years. Using these oscillations a brain switch can be implemented easily to serve as a FES control (Fig. 1).

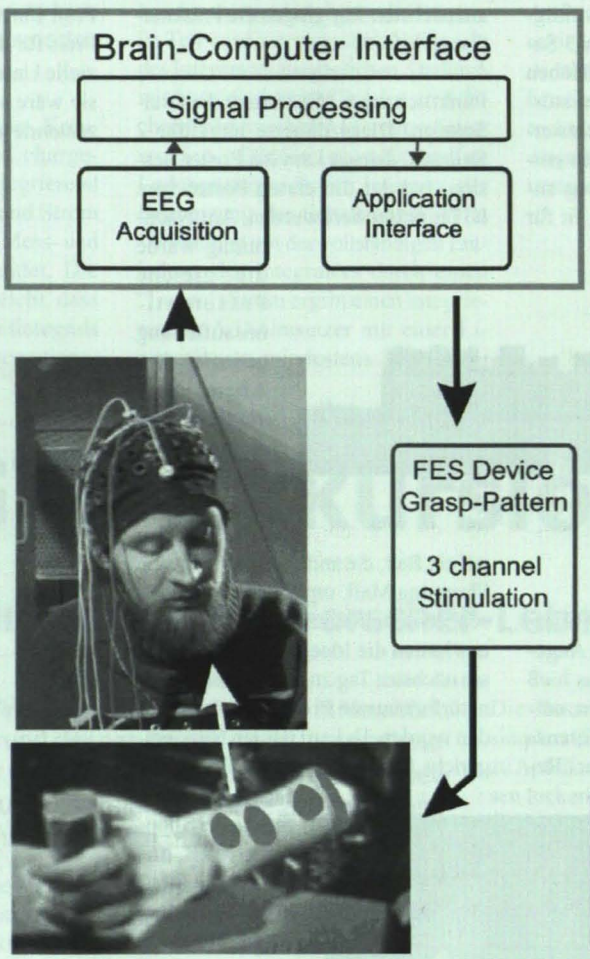

Figure 1: An EEG-based Brain-Computer Interface is used to control a FES with 3 pairs of surface electrodes (one pair at inner side of the arm). By the imagination of foot movements the patient is able to grasp e.g. a cylinder. The moving hand serves as a feedback.

The EEG is derived from two bipolar channels with electrodes 2.5 cm anterior and posterior to the positions C3 (right hand region) and Cz (region of foot). Bandpower of specific frequency bands were computed and classified by a LDA. To restore the grasp function surface electrodes were positioned at the forearm and with the help of a stimulator different grasp patterns realized.
Foot movement imagination is detected with the LDA and a threshold and a sequential switch between the different grasp patterns is possible.
This application serves a non-invasive model for the possibility of a BCI controlled FES in implanted neuroprosthesis.

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