COMMUNICATION WITH SLOW CORTICAL POTENTIALS (SCP)

Niels Birbaumer[1,2], Thilo Hinterberger[1], Andrea Kuebler[1], Jochen Kaiser[1], Ahmed El Karim[1], Juergen Mellinger[1], Barbara Wilhelm[1], Nicola Neumann[1]
[1]Institute of Medical Psychology and Behavioral Neurobiology, University of Tuebingen, Germany
[2]Center for Cognitive Neuroscience, University of Trento, Italy

The brain-computer interface ("Thought Translation Device", TTD) has been developed to re-establish communication in severely paralyzed patients who operate the device by generating shifts of their slow cortical potentials (SCP) (Birbaumer et al., 1999; Kübler et al., 2001). Ten patients have been trained with the TTD for an extended time period. The research is targeted toward understanding the learning mechanisms of SCP self-regulation. Neuroanatomical structures responsible for physiological control have been investigated in a group of patients with intractable epilepsy using functional magnetic resonance imaging (fMRI). Results indicated that attentional-motor systems were activated during cortical negativity while cortical positivity correlated with the inhibition of motor and thalamoreticular systems. Performance in physiological regulation was predicted with high accuracy by activation of inhibitory basal ganglia structures and deactivation of SMA. The research will be extended to paralyzed patients at the initial stage of amyotrophic lateral sclerosis (ALS). Psychophysical methods as well as questionnaires have been developed to reveal the relationship between successful SCP regulation and the perception of brain waves. Patients who had successfully learnt self-regulation, were able to perceive their brain state correctly (Kotchoubey et al., 2002). Conscious perception occurs after patients have already learned SCP regulation. One paralyzed patient gave a very detailed description of his mental strategy to produce negative and positive SCP shifts that corresponded exactly with his recorded brain activity (Neumann et al., submitted). Mental strategies may play an important role in the patients' perceived self-efficacy.

To assess the cognitive status of locked-in patients, a neuropsychological test system based on event-related potentials was integrated into the TTD. Different psychophysiological paradigms (e.g., oddball paradigm) were applied to completely paralyzed patients and patients in the vegetative state to evaluate their remaining processing capacities. Only patients with intact event-related potentials in at least some of the experimental tests were trained with the TTD.

To measure depression in severely paralyzed patients, a questionnaire has been developed. Existing instruments, such as Beck's depression inventory, are inappropriate, because they contain questions that cannot be answered by severely paralyzed and artificially ventilated patients (e.g., questions concerning sleep, appetite, etc.). Depression scores in a group of 76 ALS patients were significantly higher than in healthy controls (N=93), but significantly lower than in patients with unipolar depression (N=56). Quality of life was rated as satisfactory or good by 63% of the ALS patients.

To enhance the learning process of SCP regulation, transcranial magnetic stimulation (TMS) was used in a group of healthy subjects. A single-pulse was applied before each trial in the TTD self-regulation training. An effect of stimulation on cortical positivity was found, when the coil was rotated in an angle of 90º (Kübler et al., in press). Different stimulation and recording sites are presently investigated.

To increase motivation in severely ill patients, BCIs have to be adapted to individual needs. For the TTD, a special web browser was developed that enables patients to browse the internet with their brain activity. The different options which are usually offered on a web page, are presented successively and patients select the desired option by a downward cursor movement. A patient with restricted writing skills