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Extended BCI controlled alpha band neurofeedback training in schizophrenia patients

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Introduction: Cognitive deficits constitute a core feature of schizophrenia disorders [1], they are observed in more than 70% of patients, are relatively stable over time, independent of the symptomatic manifestations of the illness, and considered as prominent endophenotype [2]. Spontaneous and event-related electrocortical activity have been a prime target in this attempt. In particular, activity in the theta (4-7 Hz) and alpha (8-16 Hz) frequency range have been associated with cognitive processes like attention deployment, stimulus encoding and retention, and found to be abnormal in patients with schizophrenia. Yet, such correlative evidence seems insufficient to hypothesize neural correlates or underpinnings of cortical (dys)functions. The link between neural and functional level might be strengthened by complementing the measurement of spontaneous or task-related oscillatory activity during cognitive tests with manipulation of brain activity through neurofeedback. Alpha band neurofeedback (NF) training has been found to affect attention and memory performance in healthy subjects [3]. As learning ability is impaired in schizophrenia, the present pilot study examined the effects of online neurofeedback embedded in learning conditions favouring cortical reorganization (i.e., massed practice, motivation by feedback and success) on alpha power modulation. The aim of the study was to investigate whether patients with schizophrenia would tolerate extended training and would be able to modulate alpha power when receiving online neurofeedback.

Material, Methods and Results: Six inpatients (4 male, age range 24-43 meeting ICD-10 diagnosis of paranoid-hallucinatory schizophrenia (F20.0) were recruited at the Center of Psychiatry Reichenau, Germany. Patients' learning ability was compared to that of four healthy subjects (2 male; age range 23-25). Twenty neurofeedback training sessions were scheduled on consecutive days within 3-4 weeks. EEG was recorded with 6 Ag/AgCl electrodes. A large Laplacian spatial filter was applied, with the values on electrode location Cz used for online feedback. EEG power was calculated by means of a sliding FFT algorithm, updated every 0.5 s during each training run (BCI2000 software). Every 12 s the past data were used to update the gain and offset of online feedback. This alpha frequency-specific EEG-power (9-11 Hz) constituted the variable of online-feedback, reflecting increase or decrease in alpha power by an extending grey bar that turned green if power was modulated in the requested direction. Subjects had to increase and decrease the grey bar/feedback stimulus, i.e., their alpha amplitude. Successful trials (>50% of the feedback phase in the requested direction) were positively reinforced with a smiling face; no negative feedback was provided. All healthy subjects and 4 of 5 patients learned to increase the alpha power amplitude (significant linear trends of alpha amplitude and number of session). Start performance was at the same level in both groups (around 65% correct responses). Healthy subjects achieved 80% in the 20th session as compared to 68% in patients. Variance of performance was large in the patient group.

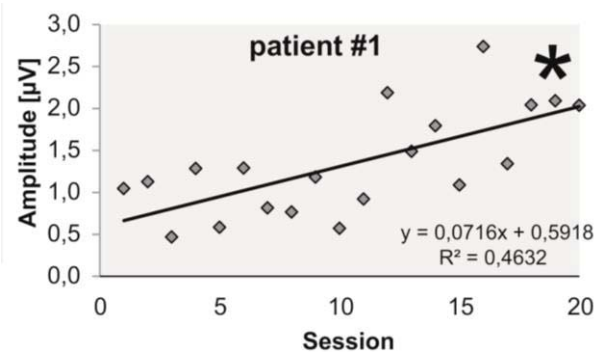

Figure 1. *Amplitude of alpha band power at Cz as a function of sessions in patient 1. The linear trend is significant and implies an increased amplitude with training. Learning trends of 3 other patients were also significant but with a smaller slope.*

Discussion: This feasibility study demonstrated (1) that alpha band neurofeedback training can be applied to in-patients with schizophrenia; this importantly implies that the training could be integrated in the clinical routine of the patients. (2) Four of 5 patients learned to modulate their alpha band amplitude. In a larger sample it has to be investigated whether the training leads to increased attentional abilities such that the attentional deficits can be remedied.

Significance: Alpha-band neurofeedback training, lasting 3 to 5 weeks can be applied in an in-patient setting and leads to increased alpha-band amplitude. Patients with schizophrenia tolerated well the training.

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