DECISION-SPEED AND INFORMATION TRANSFER IN PARAPLEGIC PATIENTS USING THE 'GRAZ BRAIN-COMPUTER-INTERFACE'

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The "Graz Brain-Computer-Interface (BCI)" transforms changes in oscillatory EEG activity into control signals for external devices or feedback. These changes are induced by various motor imageries performed by the user. For this study two different imageries (movement imagination of the right vs. left hand or right hand vs. both feet) were classified by processing two bipolar EEG-channels (positions C3 and C4). Within a few training sessions, four young paraplegic patients learned to control the BCI. The goal was to find values for the trial length enabling a maximum information transfer rate.

In accordance to the participant's performance, the decision speed (i.e. trial length) was varied (shortened) step-by-step during training. The information transfer rate was calculated for each run with respect to the number of classes, number of hits and failings and the error probabilities. After one offline-classification run at the beginning of each session, all others were feedback-runs employing a simple computer game-like paradigm: The patient saw a black screen divided into two halfs by a dotted line with a red and a green "basket" at the bottom. After a pause with a fixed length of 1 second a little red ball appeared at the top of the screen and started to fall downward with constant speed. The subjects task was to hit the red basket (which changed sides randomly from trial to trial) as often as possible. Each run consisted of 40 trials always assuring 20 right- and 20 left- sided goals in a random order. The horizontal position was controlled by the BCI-output signal and the falling speed (i.e. trial length) was varied by the investigator across experimental runs. For both EEG channels two features were extracted taking the natural logarithm of band-power values for the 10-12 Hz alpha band and the 16-24 Hz beta band. Band-power estimation employed a 5^{th}-order Butterworth-filter and simple squaring. The feature values were calculated by averaging across a 1-second time window which was shifted sample-by-sample along data. Classification of data was performed by linear discriminant analysis (LDA). The BCI- output signal was weighted by offline-calculated gain factors to lead the mean deflection for each direction to the middle of the basket.

Three out of four participants had good results after a few runs. The analysis of their last two experimental sessions, consisting of $10 - 16$ runs each, showed that the trial length can be reduced to values around 2 seconds to obtain the highest possible information transfer rate. Attainable transfer rates were between 5 and 17 bit/min depending on the participant's performance and condition. It has to be noted that these results were obtained with an average of only 20-30 training runs for each participant. Further improvement could be expected for a prolonged training. Of course, the used 'basket-paradigm' represents a task with low level of cognitive effort. The more complex the decision task is, the more time might be necessary for the BCI-decision.