UNLOCKING THE LOCKED-IN: PROGRESS IN BRAIN-COMPUTER INTERFACE

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Brain-Computer Interfaces come in two flavors, the "Control" model and the "Keyboard" model. Systems adopting the Control model aim to provide the user with continuous control over a device. The control is initiated by the subject. In such a system the controlling element is conceptualized as a switch, or a cursor, that can be applied to a large number of control situations. In general, most such 'control' systems utilize bio-feedback techniques to train the user to control the spectral composition of the EEG. The Keyboard model, on the other hand presents the subject with a structured environment, no different in the level of imposed structure than the standard keyboard. The simulated keyboard generates systematic stimuli and the subject choice of keys is inferred from the pattern of brain activity triggered by these stimuli. In most of these systems the selection is based on an analysis of Event Related Brain Potentials elicited by keyboard elements. In this report we describe a Keyboard model first described by Farwell & Donchin (EEG Journal, 1988, 70:510-523). The system employs the "oddball paradigm" generated by presenting the subject with a 6 by 6 matrix of cells. The cells contain the letters of the alphabet and a few symbols. The user focuses attention on the cell containing the character to be communicated. An "odd ball" paradigm is generated by intensifying, every 125 msec, in a random order each of the rows and columns of the matrix. Thus the subject is presented with a sequence of stimuli 16% of which contain the attended row and column. As can be expected from all we know about the oddball paradigm and P300, the row, and the column, containing the attended cell elicit a P300 component. The system examines the 600 msec epoch following each intensification and if the P300 can be detected, the selected cell can be identified. The detection of P300 required, in our original study, the averaging of at least 17.3 trials, so that the system could communicate only 2.3 characters per minute at 95% accuracy. In a subsequent study using a modified approach to the detection algorithm, including use of the discrete wavelet transform (Donchin, E., Spencer, K. M., & Wijesinghe, R, IEEE Trans. Rehab. Engineering, 2000,8, 174-179) 10 able-bodied subjects, and 5 subjects who used wheel chairs, the number of trials required for detection, increasing the transmission rate to 4.1 characters per minute at 95% accuracy for the able bodied subjects and 3.2 characters per minute for the disabled subjects. One of the major advantages of the Keyboard model is that subjects can use it without requiring prior training. The P300 is elicited in virtually all subjects who are exposed to an oddball sequence. We are currently planning to test the system with ALS patients.