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Initial evaluation of an auditory P300 brain-computer interface for the Japanese Hiragana syllabary

S. Halder[1,2*], K. Takano[1], H. Ora[1], A. Onishi[1], K. Utsumi[1], K. Kansaku[1,3]

[1]Research Institute of National Rehabilitation Center for Persons with Disabilities, Tokorozawa, Japan; [2]University of Würzburg, Würzburg, Germany; [3]The University of Electro-Communications, Chofu, Japan

*Marcusstr.9-11, 97070 Würzburg. E-mail: mailto:sebastian.halder@uni-wuerzburg.de

Introduction: Degenerative diseases that lead to the complete locked-in state (CLIS) also affect gaze control [1]. This calls for a possibility of gaze independent communication and lead to the development of auditory BCIs [2, 3]. In this study we addressed the case of a BCI system for communication with the Japanese Hiragana syllabary. A two-step selection procedure is commonly for the Hiragana alphabet [4, 5]. We investigated a two-step design using stereo headphones, stimuli with spatial cues and a training period of three sessions.

Material, Methods and Results: Six healthy participants (5 male, average age 32.6 years) and one end-user (male, age 43 years, C3/C4 spinal cord injury) participated in the study. Electroencephalography (EEG) was recorded with 16 electrodes. Stimuli were presented using stereo headphones. Classification was performed offline using shrinkage linear discriminant analysis and online with stepwise linear discriminant analysis. All participants performed three sessions on separate days and selected 25 syllables in each session.

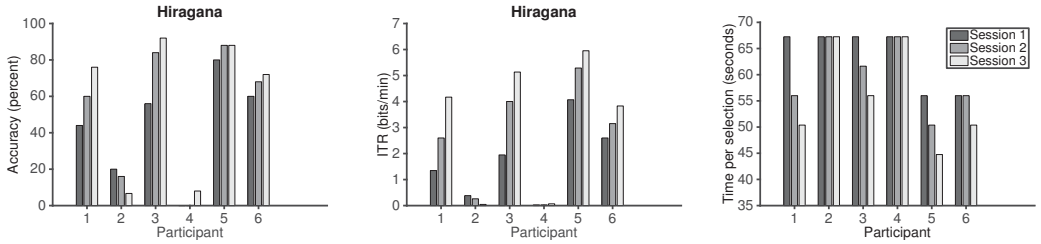

Figure 1. *Selection accuracy (left), information transfer rate (middle) and time per selection (right) of the six healthy participants.*

Offline Hiragana syllable selection accuracy in session one was 43% (SD 29, range 0 to 80), in session two 53% (SD 36, range 0 to 88) and in session three 57% (SD 39, range 7 to 92). In four out of six participants, there is a clear trend to increase of accuracy with session (see Figure 5 top row). Information transfer rate (ITR) of Hiragana selection was in session one 1.7 bits/min (SD 1.5, range 0 to 4.1), in session two 2.6 bits/min (SD 2.1, range 0 to 5.3) and in session three 3.2 bits/min (SD 2.6, range 0.1 to 6). The motor impaired end-user achieved an accuracy of Hiragana selection of 12% in the first session, 28% in the second session and 56% in the third session. Corresponding ITRs in sessions one two and three were 0.2 bits/min, 0.7 bits/min and 2 bits/min.

Discussion: Four out of six healthy participants reached accuracies above 70% in session three, which would make the use of the BCI system for communication possible. The ITR is comparable to what was achieved in other studies [4] but falls behind compared studies using a lower number of choices, e.g. for the Latin alphabet., Due to the larger number of stimuli, a longer training period may be needed.

Significance: We were able to show that healthy controls and one end-user were able to control an auditory BCI with a high number (50) of possible choices using stimuli presented with stereo headphones. Training increased performance both for the healthy controls and the end-user.

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