EEG RESPONDENCE TO AUDITORY STIMULI WITH JAPANESE LETTERS OF AN ALS-TLS PATIENT

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INTRODUCTION

ALS (Amyotrophic Lateral Sclerosis) is progressive disease. The physical impairment begins with muscular weakness of upper or lower extremities. Then, it progresses to respiratory insufficiency and facial muscle paralysis. Finally, eye movement is impaired and in TLS (Total Locked-in State). Even though such a severe situation, they are still alive. It is important to improve their QOL.

Brain computer interface (BCI) technology has high potential to make communication for TLS patients. However, most of BCI research and development projects are based on technical interests and very few BCI technologies are available for ALS-TLS patients in practical situation. There are two BCI systems commercially available for TLS patients in Japan; one system uses EEG and another system uses near infrared sensor. One of the problems of their systems is that they only allow the users to select “yes” or “no”. It is difficult for the users to express their thoughts actively.

Inoue[1)] pointed out a significant problem of current BCI systems and built a new concept of a BCI system for the ALS-TLS patients based on need investigations with the users. Most of the systems need visual function that the ALS-TLS patients are lost. He proposed the BCI system with auditory stimulation of Japanese letters and acquisition of P300.

The purpose of this study is to confirm if the auditory stimulation BCI system can detect P300 signal from the ALS-TLS patient. In order to do it, we first make sure appropriate stimulus method and analysis method with able bodied subjects. And then, we conducted experiments with the ALS-TLS patients.

AUDITORY STIMULUS BCI SYSTEM

Figure 1 shows the concept of the auditory stimulus BCI system that we built. It randomly outputs sounds of Japanese letters; “あ(A)”, “い(I)”,”う(U)”, “え(E)”,”お(O)”……; from a speaker or head set. Simultaneously, EEG is measured from the user, and then, these data are analyzed in order to detect P300. This system recognizes the letter with the most P300 as the target letter that the user wants to select.

METHODS

Experimental condition

There are three points to make sure with this experiment as follows,

1) Analysis method : Maximum analysis, frequency analysis or regression model analysis.

2) Stimulation voice : Male or female voice.

3) Stimulation rate : 1, 2, or 4 time(s)/sec.

The maximum analysis detects maximum amplitude within certain window and then calculates significant difference[1)]. The frequency analysis detects frequency power of

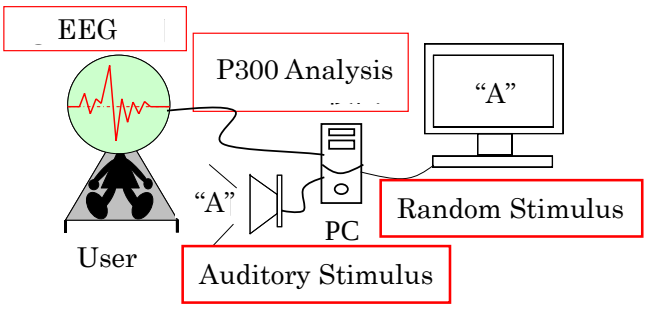

Figure 1: Concept of auditory stimulus BCI system

P300[2]. The regression model analysis estimates wave model from the data[3], and detects the maximum amplitude, then calculates significant difference.

Subject

A subject who cooperates with this experiment was a 59 year old male. He had an onset of ALS 20 years ago and has been in TLS for 10 years. He sometimes uses Mactos system (Technos Japan Co.Ltd) in daily life, that is one of the EEG-base brain communication system.

Procedure

A PC (Dell Precision M65, Microsoft Windows XP), an A/D board (National Instruments, DAQCard-6024E), a 4-chanel amplifier (Digitecs Institute, BA1104-E), 3 electrodes (Fz, Cz, Pz) and a bone conduction hearing aid (Temco Japan, Kiku-chan) constituted measurement system.

After setting the measurement system, we conducted odd-ball trials with 20% higher beep sound and 80% lower beep sound twice.

Then, a letter selection experiment was conducted. In this experiment, 5 auditory stimuli; “あ(A)”, “い(I)”,”う(U)”, “え(E)”,”お(O)”; with 20% appearance ratio each was randomly output from the hearing aid until 100 stimulations occurred. We asked the subject to select each letter twice. So, 10 sessions made 1 set for 1 condition. Totally, 6 sets were conducted; 2 voices by 3 rates.

RESULTS

Odd-ball trials

The results of the 2 odd-ball trials showed 100% recognition rate. There was no deference among the analysis methods. These results suggested that the subjects activated brain activities even though he’s been in TLS for long time.

Analysis methods

Figure 2 shows the results from each analysis method. The frequency analysis indicated lower recognition rate with every electrode position. Although there is no significant deference between the maximum analysis and the regression model analysis, the result of regression model analysis from Cz data showed the largest average recognition rate.

Stimulation methods

Figure 3 shows the results with the regression model analysis from each stimulation method. In terms of the voice, the female voice indicated the tendency of higher recognition rate than the male voice in every stimulation appearance ratio.

In terms of the stimulation appearance ratio, the 2 stimuli/sec with female voice indicated the highest recognition rate; 67%, and the 4 stimuli/sec with female voice indicated the secondly highest recognition rate; 60%.

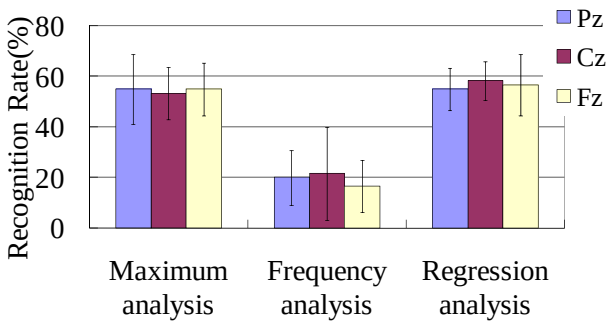

Figure 2 : Results from each analysis method.

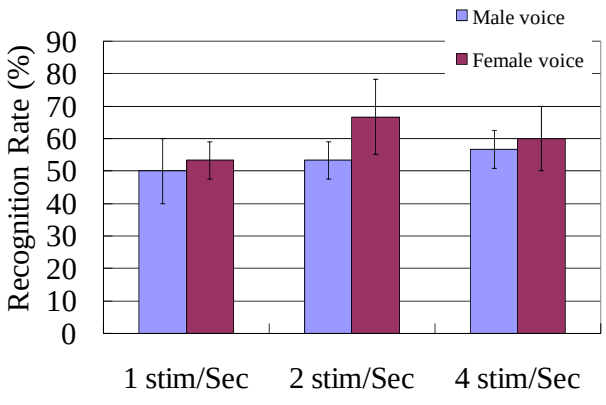

Figure 3 : Results from each stimulation method with regression model analysis.

DISCUSSIONS

Brain activities of the ALS-TLS patient

The results, that we acquired from these experiments, are incredible data, because they suggested that the brain of the subject, who had been in TLS for over 10 years, was activated according to the auditory stimuli. The data from the odd-ball trials shows some sorts of evidence. In addition, the results of experiments with auditory stimuli of Japanese letters also suggested the brain activities of this subject. This trial was one letter selection from 5 letters. Random recognition rate must be 20%, however, the results showed over 60 %. It indicated that the subjects responded to intended letter other than the rarely appeared high tone sounds.

These are only pilot data. However, these results showed important possibility of QOL improvement of ALS-TLS patients.

Data analysis method and stimulation method

As the results of this study, the regression model analysis was an effective analysis method on the auditory stimulation BCI system. The results also revealed that the 2 stimuli/sec with the female voice was an effective stimulation method. The appearance ratio is related to selection time. The results of 4 stimuli/sec with female voice indicated secondly high recognition rate. It means that 25 seconds are needed for one letter selection. This seems to be enough fast for communication. We need to take more data in order to make sure the possibility of the 4 stimuli/sec.

Auditory stimulation BCI system with Japanese letters

Japanese letters are very unique because all of the letters have one speech sound. It is a good advantage for the auditory stimulation BCI system. One stimulus corresponds to one letter.

However, it is difficult to select a letter from 46 Japanese letters using P300 signal detection. So, hierarchy structure with 3 levels must be needed. For instance, first we select first part or second part of the letter table, next select a row from 5 rows, and then select a letter from 5 letters in the row. It assumes that higher recognition rate than 67% is needed. We'll try to confirm the possibility to take higher recognition rate. In addition to it, searching better application for the ALS-TLS patients with such a low rate system is also important. Any expression from the ALS-TLS patients is very significant and impressive for the users, family members and care givers.

CONCLUSIONS

This study tried to confirm if the auditory stimulation BCI system can detect P300 signal from the ALS-TLS patient. As the results, we confirmed the brain activity of the ALS patient who has been in TLS for over 10 years. The results suggested that the regression model analysis and the stimulation condition with 2 stimuli/sec with female voice are effective methods on this system.

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