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Steady State Visual Evoked Potential Paradigm enhances the performance in classifying the distracted state during exercise

Hyunmi Lim, Jeonghun Ku

***Abstract*— Concentration while rehabilitation training is critical for positive outcome. Therefore, concentration measurement and its feedback during exercise rehabilitation could help to maximize the effect of exercise rehabilitation. In this study, we investigated whether the concentration level could be detected by using the modulation effect of SSVEP amplitude by the external focus on exercise and be superiorly classified the concentration level. For this, we used dual-task paradigm that made users distracted in focusing on performing an exercise task. The experiment was conducted on 22 healthy adults. As results, it was shown that the distract modulated SSVEP amplitude, which means it could be influenced by the user's concentration on body movements. Also, the accuracy was superior when using SSVEP feature. Therefore, this SSVEP paradigm could provide an effective rehabilitation method of providing feedback and it could induce continuous focus on motor rehabilitation.**

***Clinical Relevance*— This could be an effective method in a neurofeedback system in rehabilitation that requires concentration such as motor, cognitive, and dual task rehabilitation.**

I. INTRODUCTION

It is important to focus on task during motor learning [1], but the patients usually have difficulty concentration on rehabilitation. It could be helpful to give quantitatively measures of concentration, subsequently it could lead to strong the effectiveness improvement of rehabilitation. Recently, one of the BCI techniques, steady state visual evoked potential (SSVEP) has been introduced to measure the user's concentration on stimulation [2]. Therefore, in this study, we propose the superiority of using the SSVEP technique in classifying concentration levels during exercise.

II. METHODS

Twenty-two healthy adults were recruited in this study. The motor task was designed to move the mouse cursor and match to the moving target on the screen using non-dominant hand. There were two conditions: one is the condition in which the cursor and moving target on the screen was flickered and the other was not. In addition, each condition consisted of with and without distraction stimuli (subtraction, visual distraction) during motor tasks. EEG was collected from 19 electrodes, using a DSI-24 (wearable sensing, San Diego, USA). The classifier was designed with the support vector machine (SVM) algorithm. Features of theta (4-8 Hz), mu (8-13 Hz), beta (13-30 Hz), SSVEP for the cursor (12 Hz), and SSVEP for the target (15 Hz) amplitudes were used to classify the state of condition with distractions or not. A 10-fold cross validation was performed to evaluate the performance of the classifier.

Hyunmi Lim is with department of Biomedical Engineering, College of medicine, Keimyung University, Daegu, Korea (e-mail: lhm4159@gmail.com).

Jeonghun Ku* is with the department of Biomedical Engineering, College of medicine, Keimyung University, Daegu, Korea (corresponding author to provide phone: 82-10-3388-9051; e-mail: kujh@kmu.ac.kr).

III. RESULTS

The classification performance of concentration level during motor task was superior in flickering condition, which used SSVEP features. The classifier's average accuracy was 74% in the non-flickering condition, while average 80% of accuracy was shown in the flickering condition.

TABLE I. CONFUSION MATRIX IN FLICKERING CONDITION

	Flickering Condition		***nonFlickering Condition***	
	non Distraction	***Distraction***	***non Distraction***	***Distraction***
non Distraction	0.77870	0.22130	0.69657	0.30343
Distraction	0.17445	0.82555	0.21550	0.78450

IV. DISCUSSION & CONCLUSION

In this study, we investigated the effect of SSVEP paradigm on concentration classification. The results showed that SSVEP enhanced the improvement of the concentration classification performance during motor task. Therefore, we could conclude that the SSVEP paradigm could be an effective method in a neurofeedback system in rehabilitation that requires concentration such as motor, cognitive, and dual task rehabilitation.

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