Stable Cognitive Attention through Ventilation Pattern Manipulation in ERP-Based Brain-Computer Interfaces

Dogeun Park[1], Young-Gi Ju[1] and Dong-Ok Won[1,2]*

***Abstract*— A representative approach is event-related potential (ERP) based paradigm among the various brain-computer interface (BCI) sytems. The primary objective of this study is to investigate the effect of ventilation pattern manipulation on character recognition accuracy in the ERP-based speller paradigm. To check the possibility of the proposed methods, five subjects participated in the experiment, and each subject experienced two sessions. This study demonstrates that the proposed ventilation method is more effective than a normal method on average and lead our assumptions in a positive direction.**

I. INTRODUCTION

Event-related potential (ERP)-based speller is one of the representative paradigms in the brain-computer interface (BCI) system. However, long-term cognitive attention is required for high performance. Therefore, in a long-term experimental environment, the quality of the signal could be regraded by eye and cognitive fatigue. This contradicts the original purpose of improving performance. One previous study used meditative mindfulness induction with 6 minutes to improve accuracy [1]. Another study showed that cyclic sighing was more acute and effective than meditation in regard to physiological stress reduction [2]. This study investigated the impact of ventilation patterns on users in ERP-based BCI tasks to reduce fatigue and improve cognitive attention.

II. METHODS

As shown in Fig. 1. [A], cyclic sighing is a ventilation pattern consisting of two inhalations and one exhalation. In this study, we applied a two-minute cyclic sighing to the proposed condition. The experiment consists of two sessions: 1) Session A; 2) Session B, and two conditions: 1) Normal Condition; 2) Proposed Condition. An average of 15 minutes of break time was provided between the two sessions. The training set and test set consisted of 20 and 22 characters, respectively. Five subjects participated in and experienced each session. This study was approved by the Institutional Review Board of Hallym University [HIRD-2022-056]. We used MATLAB with the BBCI toolbox (http://bbci.de/toolbox) for pre-processing, and regularized linear discriminant analysis with shrinkage was applied with Python (version 3.7.11).

*Dong-Ok Won is corresponding author

[1]Dogeun Park, Young-Gi Ju and Dong-Ok Won are with the Department of Artificial Intelligence Convergence, Hallym University, Chuncheon, Republic of Korea B22008@hallym.ac.kr, D20504@hallym.ac.kr and dongok.won@hallym.ac.kr

[2]Dong-Ok Won is with the College of Medicine, Hallym University, Chuncheon, Republic of Korea dongok.won@hallym.ac.kr

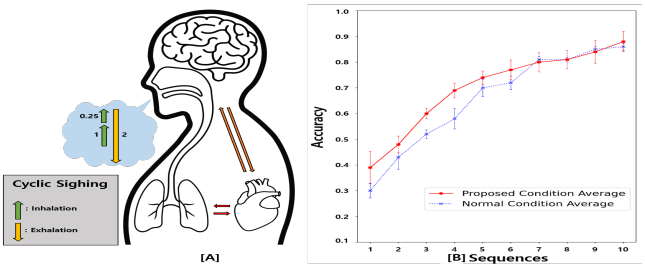

Fig. 1. [A]: Cyclic sighing consists of two inhalations and one exhalation. [B]: Comparison of mean accuracy per sequence between two conditions.

III. RESULTS

As shown in Fig. 1. [B], the proposed condition has a higher character recognition rate than the normal condition in most of the sequences. In particular, there is a large performance difference in 1-6 sequences.

IV. DISCUSSION AND CONCLUSION

We examined the impact of respiratory patterns with a 2-minute cyclic sighing on users in ERP-based BCI tasks. In Fig. 1., overall, the proposed ventilation pattern showed higher performance than the normal respiratory condition. This suggests that the proposed method could maintain robust performance when considering eye and cognitive fatigue. The ERP-based speller paradigm generally saturates its performance as the sequence progresses. In light of this, our proposed method could achieve higher, more robust performance even in a small number of sequences and could lead to our assumptions in a positive direction.

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