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Slow EEG fluctuation and heart rate variability reflects flexible adjustment to cognitive load

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***Abstract*—We explored functions of the brain and autonomic activity accompanying cognitive load by examining effects of time series EEG power of the alpha band and heart rate variability (HRV) on task accuracy and reaction time during n-back tasks. Enhancement of the alpha power fluctuation at a very low frequency (0.01Hz) and greater HRV reflecting parasympathetic activity during a 3-back task were associated with higher task performance and stability of reaction time in the task, suggesting that ability of the brain to flexibly adjust behaviors to cognitive load is affected by peripheral bodily activity.**

I. Introduction

We showed that fluctuations of the EEG alpha power at a very low frequency range reflects ability of the brain to flexibly adjust behaviors corresponding to cognitive load [1]. Though the autonomic nervous system (ANS) has also been reported to affect cognitive performance [2], details of interplays of the brain and ANS in such behavioral adjustment are not fully elucidated. We explored this issue by examining effects of the slow EEG fluctuation and heart rate variability (HRV) on task performance of the n-back tasks.

II. Methods

Healthy participants (N = 12) conducted a 0-back task (low cognitive load) and a 3-back task (high cognitive load), with 3 second inter-trial intervals, for approximately 6 minutes, respectively. EEG signals from frontal areas and cardiac activity from photoplethysmogram were measured. We analyzed fluctuation of time series of EEG power in the alpha frequency bands to estimate brain states [1], an index of HRV: root mean square of successive differences (RMSSD) of R-R intervals indicating parasympathetic activity, as well as task accuracy and reaction time.

III. Results and Conclusion

As shown in Fig.1, reaction time dominantly varied among trials in the 3-back task, comparing to the 0-back task (A). Fluctuation of the 2nd-order time series of the alpha power of EEG showed increase at around 0.01 Hz in the 3-back task, compared to the 0-back task (B). Participants indicating greater enhancement of the slow alpha power fluctuation (C) and greater RMSSD during the 3-back task (D) showed significantly higher task accuracy in the task. Greater RMSSD also showed a tendency of a link with stability of behaviors (less variability of reaction time) in the 3-back task (E). The correlation between the slow alpha power fluctuation and RMSSD is not significant (F).

Taken together, these results suggest that parasympathetic activity can affect behavioral adjustment during a high cognitive load situation, probably via some modulation of brain functions. Neural mechanisms of this phenomenon should be clarified in future.

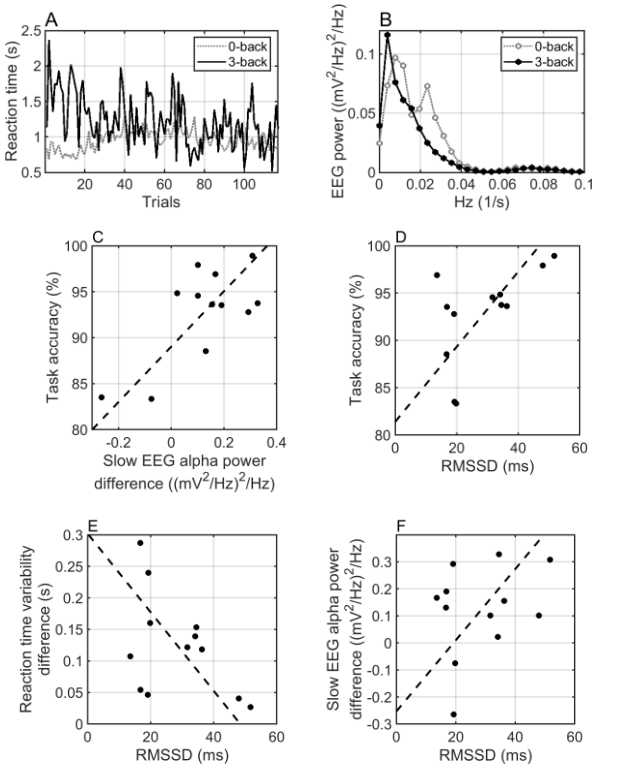

Figure 1. Association of reaction time, EEG fluctuation, HRV(RMSSD), and task accuracy.

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