Abstract—A visual selective response task was performed under a very low transcranial random noise stimulation (tRNS) condition and its sham condition, which were applied on real-time basis. The tRNS reduced the reaction time of the task comparing with the sham and enhanced forward phase synchronization.

I. INTRODUCTION

Brain stimulation techniques such as transcranial direct current stimulation (tDCS) [1], transcranial alternating current stimulation (tACS) [2], and transcranial random noise stimulation (tRNS) [3] facilitate and/or inhibit brain functions. These techniques employ current intensity of 1-3 mA. Typical impedance between two electroencephalogram (EEG) electrodes is around 5 kΩ. The artifact voltage superimposed on EEG reaches several V or higher. Thus, simultaneous EEG (10 µV order) recording is impossible with such current stimulation. If the current intensity is reduced to 10 nA order, simultaneous EEG recording can be possible. There are, however, doubts whether very low current stimulation shows facilitation and/or inhibition effect. If it effects, what are differences on EEGs?

II. MATERIALS AND METHODS

A simple visual selective response task was performed. One of two targets (one was for click by the right index finger, the other for click by the right middle finger) was randomly selected and randomly presented around the fixation point for each trial. 128 trials of tRNS and 128 trials of its sham were randomly placed with SOA of 0.8-1.4 s. The tRNS (current: 14 nArms, frequency band: <100Hz) was applied via the electrode F3 and the right earlobe electrode (for reference). Subjects were asked to mouse-click as soon as they recognize the targets as instructed. EEG was recorded during the visual selective response task. The electrode F3 was selected only because F3 is near the left pre-motor cortex, which seemed to be activated for this task.

Phase-interpolated averaging can separately extract evoked and ongoing rhythmic activities in EEG epochs [4,6]. Phase-compensated averaging can clarify directional phase synchronization relationships among EEG channels [5,6]. Now, the instantaneous phases of the alpha-band (8-13 Hz) rhythmic EEG activities of the electrodes F3 and Iz under the visual selective response task were first calculated by phase-interpolated averaging. Directional phase synchronization relationships of the wide-band (1-52Hz) EEG activities between these electrodes were then analyzed by phase-compensated averaging based on the alpha-band instantaneous phase. The electrode Iz was selected only because Iz is near the primary visual cortex, and therefore Iz and F3 seemed to cooperate for this visual selective response task.

Five people were participated in this experiment after having given written informed consent. This study received ethical approval from the University of Tokyo.

III. RESULTS AND DISCUSSIONS

Even such weak tRNS not so often but sometimes showed a significant reaction time reduction effect comparing with the sham (two people out of five, with Mann-Whitney U-test: \( p<0.05 \)). Note that this effect was not an aftereffect. This effectiveness might be thus relevant to this real-time tRNS application.

Backward phase synchronization from the alpha-band F3 activity (instantaneous phase reference latency: 150 ms) to the wide-band Iz activity was observed under both the sham and tRNS conditions. However, forward directional phase synchronization, namely from the alpha-band Iz to the wide-band F3, was only observed under the tRNS condition. This forward synchronization might facilitate conducting the visual selective response task.

IV. CONCLUSION

Very low current stimulation to the brain would be suitable for real-time cognitive and behavioral event-related potential (ERP) experiments. The mechanism of facilitation and/or inhibition effects by current stimulation would be clarified by ERP analyses.

REFERENCES