2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Desynchronization of Alpha Rhythm during Exchanging Semantic Words—MEG Hyperscanning Study

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Abstract— **Spontaneous brain rhythms were recorded when two participants uttered words by turns. The amplitude modulation of the rhythms were compared within each 62 brain region between semantic and non-semantic conditions. It was found that the amplitude of alpha-band rhythm (8–12 Hz) during thinking the next utterance was significantly lower for the semantic condition than that for the non-semantic condition in several brain regions, mainly in the left temporal area. This result suggests that the left temporal area is involved in generating semantic words in communication.**

I. INTRODUCTION

Communication is important to establish social connection. In dialog, information is exchanged and influences each other continuously between at least two-persons. Therefore, hyperscanning, i.e., simultaneous recording of multiple brain activities, are essential to investigate communication as brain functions. Ahn et al. [1] reported differentiate brain activities between interactive and non-interactive utterances of two-persons by MEG (magnetoencephalography) hyperscanning. However, meanings are essential in dialog. Therefore, in this work, we hyperscanned brain activities when two persons exchanged semantic words alternatively.

II. METHODS

Seven pairs, 14 healthy adults participated (aged 22.7±0.9 years, 8 females, all right-handed). The experiment was composed of semantic condition and non-semantic condition. In semantic condition, each participant uttered a word associating to others' utterance alternatively with 5 s interval. They could utter noun, adjective, verb, or adverb. In non-semantic condition, each participant uttered consecutive more than 3 syllables in Japanese alphabet (Fig. 1). MEG of the paired participants were recorded simultaneously by our MEG hyperscanning system [2]. The experimental protocol involving human subjects described in this report was approved by Ethics Committees of School of Medicine, Hokkaido University. Written informed consent was obtained from each participant prior to the experiments.

MEG data of each subject were band-pass filtered with 1–40 Hz and cleaned by ICA. Source brain activities were estimated by minimum-norm estimation at 15,002 vertices on the cortex of the template brain and band-pass filtered with alpha-band (8–12 Hz). The amplitude of the alpha-band rhythm was calculated by Hilbert transformation at each vertex. The mean amplitude within each target time window, i.e., thinking times for the next utterance (see Fig. 1), was normalized by that of a relevant baseline. The normalized amplitudes were averaged over vertices within each 62 brain region based on the Mindboggle atlas. The normalized amplitude of brain regions were compared between conditions via 2-way RM ANOVA (condition (2) x brain region (62)).

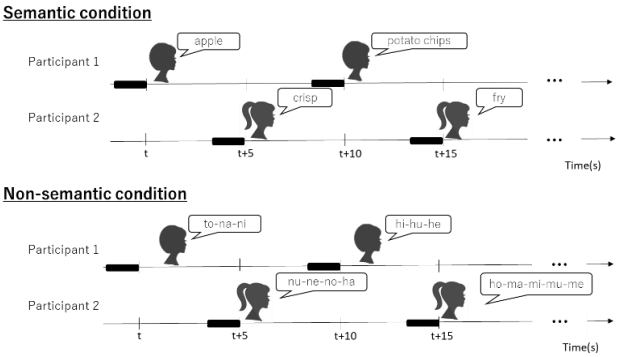

Figure 1. Schematic diagram of one trial. In the semantic condition (upper), each participant uttered a word associating to others' utterance. In the non-semantic condition (lower), each participant uttered consecutive syllables in Japanese alphabet. The target time windows, denoted by black bold lines, were set as thinking time for the next utterance.

III. RESULTS

Results of the 2-way RM ANOVA (condition x brain region) showed a significant main effect of brain region ($p<0.01$) and interaction ($p<0.01$). Post hoc t-test indicated the amplitude of alpha-band rhythm was significantly lower for the semantic condition than that for the non-semantic condition in 10 brain regions, the left inferior temporal gyrus (ITG) and the left middle temporal gyrus (MTG), for instance.

IV. DISCUSSION & CONCLUSION

It has been known left MTG is involved in detecting whether the meaning of a word matches to a lexical representation [3]. In this study, left MTG and ITG were activated significantly in semantic condition. These results suggest that left temporal area reflects the process of understanding and responding to others' utterance in communicative situations.

REFERENCES

[1] S. Ahn et al., "Interbrain Phase Synchronization during Turn-Taking Verbal Interaction—A Hyperscanning Study Using Simultaneous EEG/MEG," Hum. Brain Mapp., vol. 39, no. 1, pp. 171–188, 2018.

[2] K. Yokosawa et al., "A Magnetoencephalographic Hyperscanning System Enabling Natural Face-to-face Communication," Conf Proc IEEE Eng Med Biol Soc, Berlin, 2019.

[3] J. Rissman et al. , "An Event-Related fMRI Investigation of Implicit Semantic Priming," J. Cogn. Neurosci., vol. 15, no. 8, pp. 1160–1175, 2003.

*This work was supported by KAKENHI 20H04496.

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