EEG Source Imaging of Covert Articulation Using a Template Brain

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***Abstract*— This study investigated EEG source imaging of EEG signals measured during covert vowel articulation without using individual anatomical MRI and an fMRI prior but using a template brain. Grand-averaged of time course of the absolute Z-scored current amplitudes in some labeled regions, such as left caudal middle frontal gyrus, showed different changes for different covert vowel articulation.**

***Clinical Relevance*— This study provides feasibility of EEG source imaging without using MRI as basic research.**

I. Introduction

Decoding covert vowel articulation from EEG signals has been studied [1]. In the study, EEG source imaging (ESI) obtained by individual anatomical MRI was used as input of a decoder and functional MRI was used for a prior of the decoder. In this study, we investigated ESI of EEG signals measured during covert vowel articulation without using individual anatomical MRI and an fMRI prior.

II. Methods

We recorded EEG signals from eleven healthy male participants in their twenties. The experimental procedure followed a previous study [1]. We instructed the participants to recall two Japanese vowels (/a/ and /i/) in response to the auditory stimuli. The auditory stimuli were 0.25 s recordings of /a/ and /i/ and white noise of the same duration. Participants performed four recalls after offset of the auditory stimuli. We instructed them to suppress recall during white-noise trials. We recorded scalp EEG data using a 32-channel active electrode system (actiCHamp Plus, Brain Products GmbH). We positioned electrodes according to the international 10–20 system and placed the reference electrode at Fz. The stimulus protocol consisted of 30 blocks of five trials. The auditory stimuli were presented in random order in the 150 trials. We applied a band-pass filter (0.5–40 Hz) to the raw EEG data using a zero-phase FIR filter. We applied artifact subspace reconstruction to attenuate high-amplitude transient artifacts. We re-referenced the cleaned data to the common average of all electrodes. We segmented the continuous recordings to epochs ranged from –0.5 s to 3.0 s relative to stimulus onset. We applied baseline correction using a time interval before the onset as a baseline period. We performed extended infomax independent component analysis and removed components classified as muscle, ocular, cardiac, or line noise (probability ≥ 0.8). We performed ESI on each epoch using a three-layer head model derived from the fsaverage cortical surface template. We applied exact low-resolution electromagnetic tomography (eLORETA). We constrained dipole orientations at 8,196 vertices to be normal to the cortical surface. We transformed time series on the vertices into absolute Z-score values, calculated relative to the baseline period, to obtain standardized current amplitudes. We adopted the Desikan–Killiany (DK) atlas for anatomical labeling. We averaged the Z-score values across all vertices within each label and then time-averaged over 1.0–2.0 s after the offset of the auditory stimuli and finally averaged across participants (n=11) for each of the two auditory recall conditions (/a/, /i/) and the recall-suppression condition (white noise).

III. Results

Fig. 1 shows that the grand-averaged absolute Z-scores in the /a/ condition rose at DK indices 2, 3, 19, 21, 23, 25, 28, 29, 37, and 38, corresponding to the left lateral prefrontal regions (pars opercularis/triangularis, rostral/caudal middle frontal gyrus, and superior frontal gyrus), left pre-/postcentral gyrus, bilateral caudal anterior cingulate gyrus, and right caudal middle frontal gyrus.

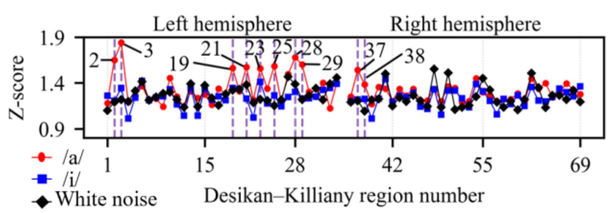

Figure 1. Group-averaged absolute Z-scores (1.0–2.0 s) for /a/, /i/, and white noise (DK indices: left hemisphere 1–34; right hemisphere 36–69; 35 unused).

IV. Discussion & Conclusion

Rises in the Z-score in the /a/ condition partially aligned with the prior reports [1], particularly in the left caudal middle gyrus (DK 3, 28). In contrast, pronounced rises in the left pre-/postcentral gyrus and bilateral caudal anterior cingulate cortex and the absence of rises the right inferior frontal gyrus, and left inferior temporal gyrus, left hippocampal regions likely were not shown in the reports. It might be caused by differences in inverse-model constraints between the template-based EEG without individual MRI/fMRI priors and the MRI-informed, fMRI-constrained source models.

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References

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