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研究論文

Spatiotemporal Human Brain Activities on Recalling Body Names

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Abstract

The authors measured electroencephalograms (EEGs) from subjects who were looking at line drawings of body parts and recalling their names silently. The equivalent current dipole source localization (ECDL) method is applied to the event related potentials (ERPs): summed EEGs. ECDs are located in the ventral pathway. The areas are related to the integrated process of visual recognition of pictures and the retrieval of words. Some of these areas are also related to image recognition and word generation. ECDs are localized to the primary visual area V1, to the ventral pathway (ITG: Inferior Temporal Gyrus), to the parahippocampus (ParaHip), the right angular gyrus (AnG), to the right supramarginal gyrus (SMG) and to the Wernike's area. Then ECDs are localized to the Broca's area, to the post central gyrus (PstCG) and to the fusiform gyrus (FuG), and again to the Broca's area. These areas are related to the integrated process of visual recognition of pictures and the retrieval of words. Some of these areas are also related to image recognition and word generation. And process of search and preservation in the memory is done from the result of some ECDs to the paraHip.

I. Introduction

According to research on the human brain, the primary process of visual stimulus is first processed on V1 in the occipital robe. In the early stage, a stimulus from the right visual field is processed in the left hemisphere and a stimulus from the left visual field is processed in the right hemisphere. Then the process goes to the parietal associative area [1].

Higher order processes of the brain thereafter have their laterality. For instance, 99% of right-handed and 70% of left-handed have their language areas in the left hemisphere, the Wernicke's area and the Broca's area [2], [3], [4].

By presenting words written in *kanji* (Chinese characters) and others written in *hiragana* (Japanese alphabet) to the subjects, researchers measured electroencephalograms (EEGs). Some of the present authors have used the same methodology as the previous research [6]. Then those stimuli and both data were summed and averaged according to the type of the stimuli and the subjects. As a result, event related potentials (ERPs) were obtained. ERPs peaks were detected and analyzed by equivalent current dipole source localization (ECDL) [5] at that latency using three dipoles model. In both the recognition of the *kanji* and *hiragana*, researchers localized equivalent current dipole (ECD) nodes from early components of ERPs to the V1, V2, and the inferior temporal gyrus (ITG). After that, ECDs were

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localized to the Wernicke's area and the Broca's area. These results agree with the results on MEG, PET, or fMRI [6].

On the other hand, clinical lesion studies have shown that lesions causing disabilities of naming and comprehension of objects are dissociated depending on the target categories, e.g., artificial or biological things. These symptoms are called category-specific disorders [7].

Using the same methodology as that in the above mentioned research [6], [8], [9], [10], [11], [12], [13], some of the present authors elucidated spatiotemporal human brain activities during language or image recognition.

In the present study, we measured electroencephalograms (EEGs), in order to investigate the brain activity while subjects were looking at line drawings of body parts and recalling the name of presented body parts. The data were summed and averaged according to the type of stimuli in order to obtain event related potentials (ERPs). Peak ERPs were detected and analyzed using the equivalent current dipole source localization (ECDL) method [5]. The paper is a continuation of the previous research [13].

II. EEG Measurement Experiments

One subject was a 22-year-old female (MN) that had normal visual acuity. She was left-handed, and, from the previous experiment, her dominant language area was considered to be located in the right hemisphere. The other subject was a 22-year-old male (HT) that had also normal visual acuity. He was right-handed. The subjects put on 19 active electrodes and watched a 21-inch CRT 30cm in front of her. Their heads were fixed on a chin rest on the table.

Each image was displayed on the CRT. Stimuli were simple monochrome images (line drawings) of parts of the human body. Images were of a foot, mouth, finger, ear, and hand (Fig. 1). First, a fixation point was presented, and then a stimulus was presented. Both of those durations were 3000 msec. EEGs were measured on the multi-purpose portable bio-amplifier recording device (Polymate AP1524; TEAC) by means of the electrodes; the frequency band was between 1.0 and 2000Hz. Output was transmitted to a recording PC.

We measured the subject's EEGs on each visual stimulus. So as to effectively execute the ECDL method, EEGs were summed and averaged according to the type of human part to get event-related potentials (ERPs). To each subject, we tried the experiment twice. So as to distinguish these experiments, we labelled as HT1, HT2, MN1 and MN2 to each ERP.

According to these ERPs, the following three characteristics were found: (1) A positive peak existed around the latency of 400msec; (2) A large negative peak existed around 450msec; and (3) A positive peak appeared around 500msec, attenuated gradually, and converged around 700msec (Fig. 2).

Then the ECDL method was applied to each ERP. Because the number of recording electrodes was 19, three ECDs at most were estimated by use of the PC-based ECDL analysis software "SynaCenterPro [5]" from NEC Corporation. The goodness of fit (GOF) of ECDL was more than 99 %.

Fig. 1 Presented images of human body part.

III. Results of ECDL Analysis

In these figures from Fig. 3 to Fig. 6, the left picture shows a sagittal view, the middle an axial view and the right a coronal view. From these three views, one can understand a location of the ECD in a three dimensional space. Localized ECDs by the ECDL method are indicated by white dots in these figures.

Some examples of localized ECDs are depicted in Fig. 3, Fig. 4, Fig. 5 and Fig. 6. These processes are done in series or in parallel. The relationship between ECDs and its latency is summarized in TABLE 1 and TABLE 2.

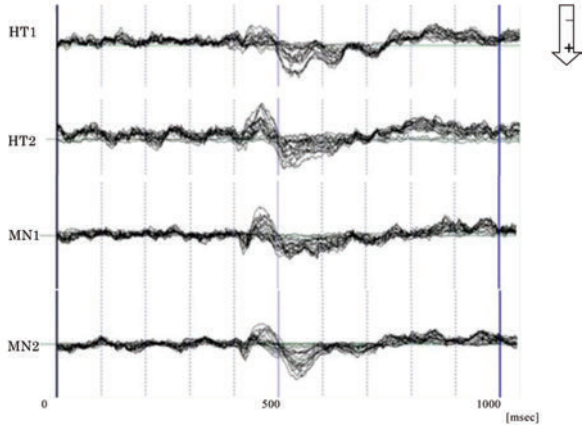

Fig. 2 Examples of Event-Rerated Potentials (ERPs) by the present experiment

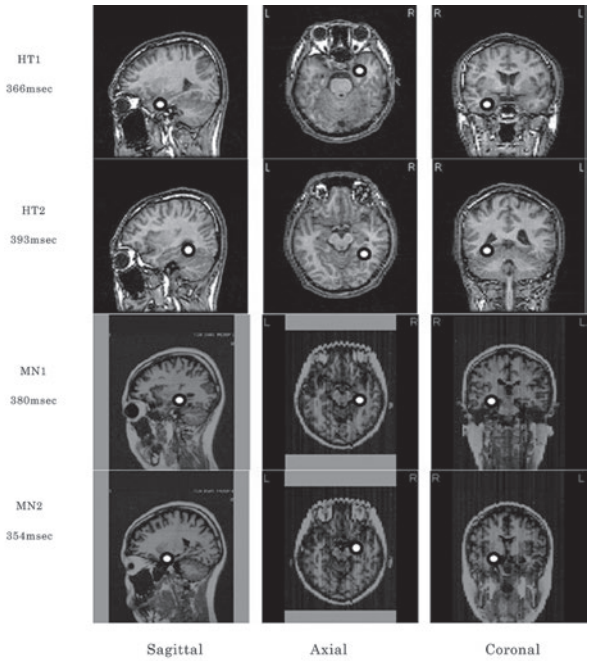

Fig. 3 ECDs localized to the Right ParaHip

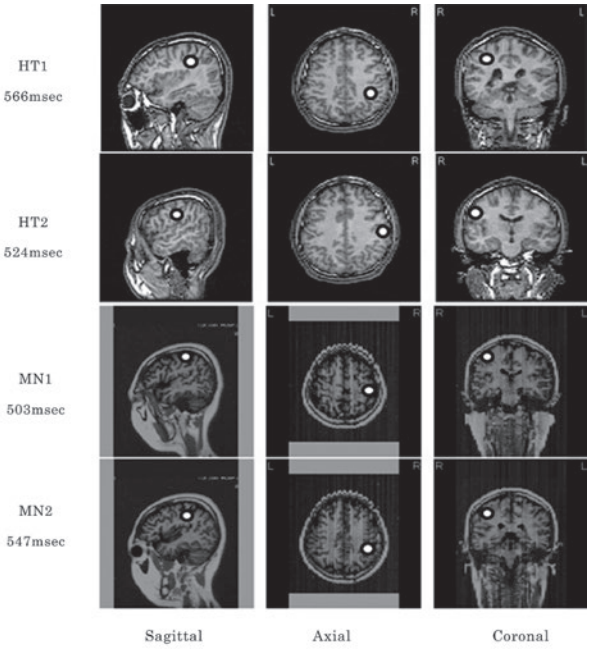

Fig. 4 ECDs localized to the Post Central Gyrus

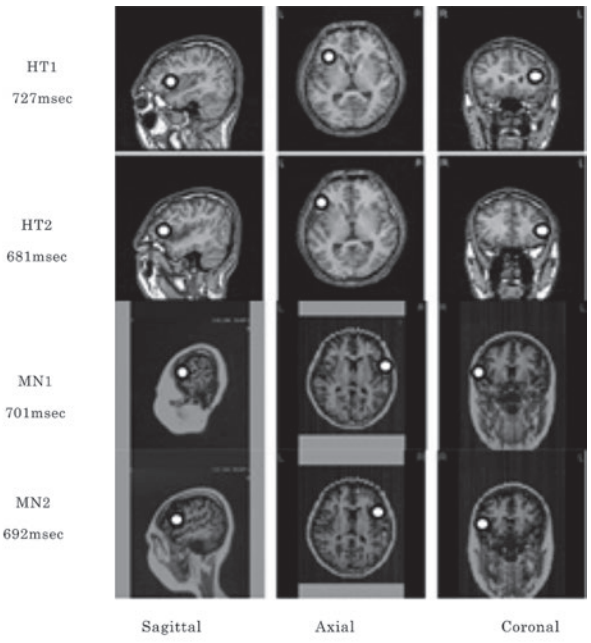

Fig. 5 ECDs localized to the Broca's area

TABLE I RELATIONSHIP BETWEEN LOCALIZED SOURCE AND ITS LATENCY (HT)

subject	V1	ITG	Right ParaHip
HT1	119	326	366
HT2	131	323	393
	Right AnG	Wernicke	Right Broca
HT1	373	474	524
HT2	427	455	485
	Right ParaHip	Right PstCG	Left FuG
HT1	530	566	537
HT2	506	524	556
	Right ParaHip	Broca	
HT1	610	727	
HT2	590	681	[msec]

TABLE II RELATIONSHIP BETWEEN LOCALIZED SOURCE AND ITS LATENCY (MN)

subject	V1	ITG	Right ParaHip
MN1	127	292	380
MN2	106	334	354
	Right SMG	Broca	Wernicke
MN1	443	457	477
MN2	430	455	483
	Right ParaHip	Right PstCG	Right FuG
MN1	481	503	546
MN2	494	547	548
	Right ParaHip	Right Broca	
MN1	575	701	
MN2	592	692	[msec]

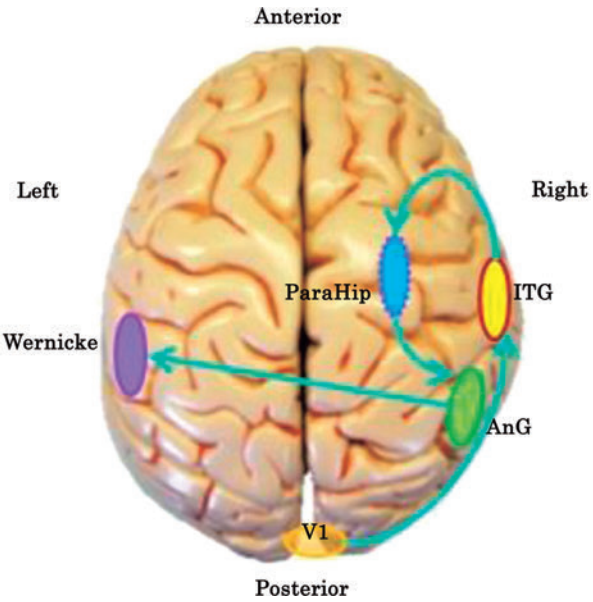

Fig. 6-1 Input pathway (HT): Bold line denotes ECD on surface, Dash line denotes ECD inside.

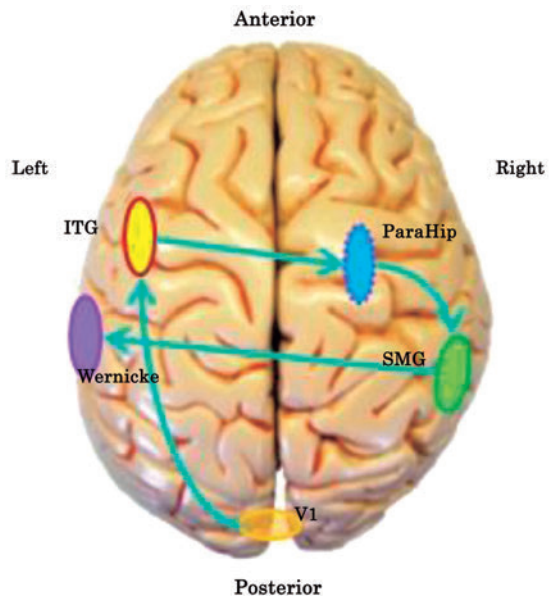

Fig. 6-2 Input pathway (MN): Bold line denotes ECD on surface, Dash line denotes ECD inside.

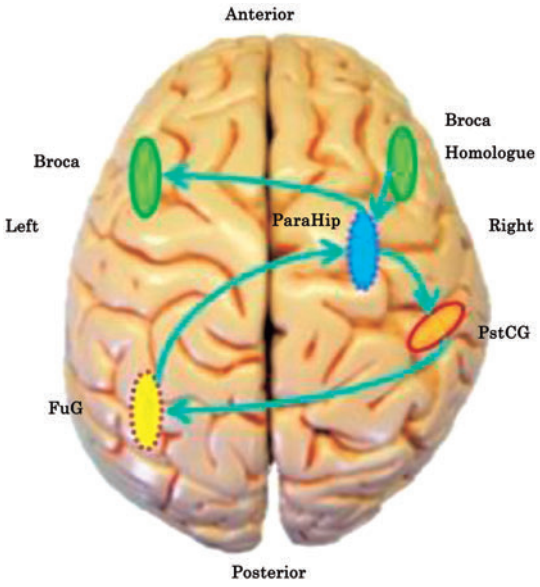

Fig. 7-1 Output pathway (HT): Bold line denotes ECD on surface, Dash line denotes ECD inside.

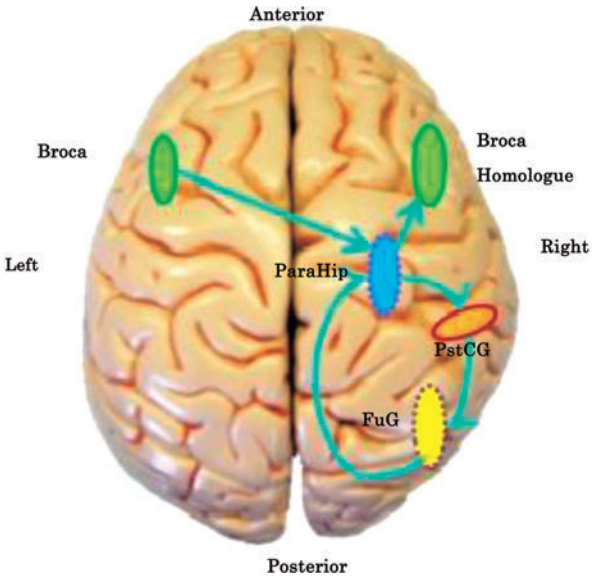

Fig. 7-2 Output pathway (MN): Bold line denotes ECD on surface, Dash line denotes ECD inside.

IV. Discussion

In this study, we call the pathway among early visual recognition process and language recognition the input pathway. And we call the pathway among higher recognition and recalling the output pathway.

According to the subject HT, the input pathway was observed: V1 → right ITG → the right ParaHip → the right angular gyrus (AnG) → the Wernicke's area (Fig. 6-1), and the input pathway of the subject MN, was observed: V1 → left ITG → the right ParaHip → the right supramarginal gyrus (SMG) → the Wernicke's area (Fig. 6-2).

The output pathway of the subject HT was observed: the right Broca's area (Broca's homologue) → the right ParaHip → the right post central gyrus (PstCG) → the left fusiform gyrus (FuG) → the right ParaHip → the Broca's area (Fig. 7-1). And the output pathway of the subject MN was observed: the Broca's area → the right ParaHip → the right PstCG → the right FuG → the right ParaHip → the Broca's homologue (Fig. 7-2). Both of output pathways included the PstCG is supposed as somatosensory area.

The input pathway had been found in other studies [10], [11], and the output pathway had been found to another study [9]. These results show that the brain activities for observing static visual stimuli are related to the same pathway regardless of visual stimuli (e.g. character, symbol or line drawing). And the output pathway is found to other studies [8], [9]. These results show that the brain activities on recalling process are related to the same pathway regardless of task (e.g. direction or name).

Almost the same pathways are found to the subjects HT and MN in case of recalling a name of "mouth." However, the estimated areas of the Broca and FuG are opposite between HT and MN. It is said that the dominant language area is opposite in some left-handed person, therefore, the dominant language area is supposed to be different between these two subjects.

IV. Conclusion

In this study, we estimated human brain activities while human subjects who were looking at line drawings of the human body parts and recalling their names silently. ECDs were localized to the word generation area and the image recognition area.

In the previous research, we have detected a pathway regarding with the recalling of the names of body parts. By use of ECDL method, ECDs were localized to the right angular gyrus, the right fusiform gyrus and the right temporal pole. These areas are related to the integrated process of visual recognition of picture and the recalling of word. Some of these areas are also related to the image recognition and word generation. The paper is a continuation of the previous research [13].

In case of the subject HT, estimated activities concentrate to the left hemisphere, e. g. the Broca's area and the Wernicke's area, so his language area is supposed to be the left hemisphere.

In case of the subject MN, left-handed person, although the input pathway is the same as HT, the out pathway is different from HT. It should be noted that there might be the difference of the dominant hemisphere between input and output of the language on her, or she might use both hemispheres in language process.

Because of some activities on the right ParaHip is observed, the process of search and preservation to the memory is done here. Further, we observe activities on the PstCG, which is a part of the somatosensory area, so the subjects made some somatosensory process during recalling the name of "mouth".

Acknowledgment

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