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研究論文

Spatiotemporal Human Brain Activities on Recalling Fruit Names

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Abstract

The authors have measured electroencephalograms (EEGs) from subjects observing images of fruit and recalling them silently. The equivalent current dipole source localization (ECDL) method has been applied to those event related potentials (ERPs): averaged EEGs. ECDs were localized to the primary visual area V1 around 100 ms, to the ventral pathway (TE) around 270 ms, to the parahippocampal gyrus (paraHip) around 380 ms. Then ECDs were localized to the Broca's area around 450 ms, to the fusiform gyrus (FuG) around 600 ms, and again to the Broca's area around 760 ms. Process of search and preservation in the memory has been done from the result of some ECDs to the paraHip.

Keywords— equivalent current dipole source localization; recalling; fruit names; spatiotemporal brain activities

I. Introduction

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

Higher order process of the brain thereafter has its laterality, for instance, 99% of right-handed and 70% of left-handed have their language area on the left hemisphere as the Wernicke's area and the Broca's area [2], [3]. There are some precedent studies on the sight agnosia [4], [5], [6], [7]. And one of the present authors has been investigating clinical studies for the sight stimulation [8], [9].

Some of the present authors have used the same methodology as the preceding research. By presenting Kanji word and Hiragana word to the subjects, they measured electroencephalograms (EEGs) under those stimuli and both data were summed and averaged according to the type of the stimuli and the subjects in order to get event related potentials (ERPs). Each peak of ERPs were detected and analyzed by the equivalent current dipole source localization (ECDL) [10] at that latency by use of two dipole model. In both cases of Kanji and Hiragana recognition, they localized equivalent current dipole (ECD) nodes from early components of ERPs to the V1, V2 and the inferior temporal gyrus (ITG), after then ECDs are

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localized to the Wernicke's area and the Broca's area [11]. These results agree with the results on MEG, PET or fMRI.

On the other hand, from the clinical lesion studies, it is known that the lesions causing disabilities of naming and comprehension of objects are dissociate depending on the target categories, e.g. artificial or biological things. These symptoms are called category-specific disorders [12].

Using the same methodology as the preceding research [13], [14], [15], [16], [17], [18], [19], [20], some of the present authors had cleared human brain activities during language recognition or during image recognition.

In the present study, we had measured electroence- phalograms (EEGs), in order to investigate the brain activity during watching the line drawings of fruit and recalling a name of presented fruit. And both data were summed and averaged according to the type of the stimuli in order to get event related potentials (ERPs). Each peak of ERPs were detected and analyzed by the equivalent current dipole source localization (ECDL) method [10].

II. EEG Measurement Experiments

One subject YY is a 22 year-old female and has normal visual acuity. She is right handed. The other subject KS is a 22 year-old male and also has normal visual acuity. He is right handed. The subjects put on 19 active electrodes and watched the 21 inch CRT 30 cm in front of them. Their heads were fixed on the table on a chin rest.

Each image was displayed on the CRT. Stimuli are simple monochrome image (line drawings) of fruit. Presented images were strawberry, persimmon, cherry, etc. (Fig. 1). First, a fixation point was presented, then a stimulus was presented, both of them were during 3000 ms (Fig. 2). We directed for subjects to read the name silently. EEGs were measured on the multi-purpose portable bio-amplifier recording device (Polymate AP 1524, TEAC) by way of the electrodes and the frequency band is between 1.0

Upper: strawberry, persimmon, cherry, watermelon, pineapple
Lower: banana, grape, melon, peach, and apple

Fig. 1. Presented images of fruit.

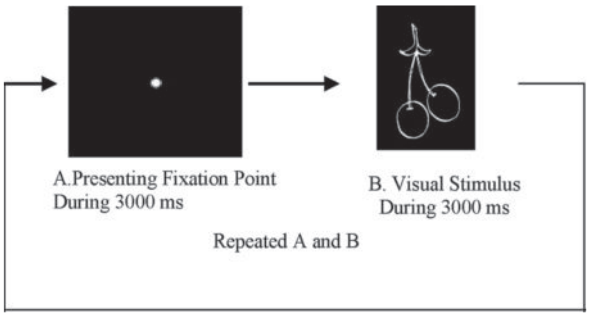

Fig. 2. Time chart of the present experiment

and 2000 Hz. Outputs were transmitted to a recording PC.

We have measured EEGs on each visual stimulus. So as to effectively execute the ECDL method, both data were summed and averaged according to the type of parts to get event-related potentials (ERPs). An example of ERPs is shown in Fig. 3.

Then the ECDL method was applied to each ERP. Because of the number of the recording electrodes was 19, theoretically, at most three ECDs could be estimated by use of the PC-based ECDL analysis software "SynaCenterPro [10]" (NEC Corporation). The goodness of fit (GOF) of ECDL was more than 99 %.

III. Results of ECDL Analysis

After the latency around 400 ms, the ECDs were localized to the right ParaHip (R ParaHip) (Fig. 4), the right fusiform gyrus (FuG), the Broca's area (Fig. 5), the right ParaHip, the Broca's area, and the right fusiform gyrus (FuG).

In these figure Fig. 3 and Fig. 4, the left picture shows a sagittal view, the middle an axial view and the right a coronal view. From these

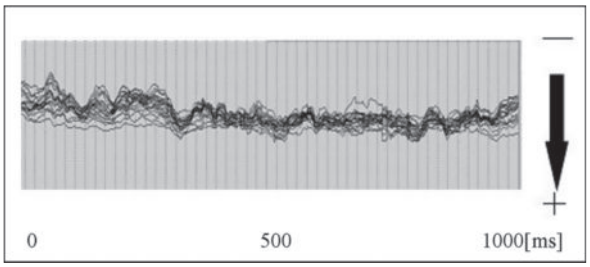

Fig. 3. Event Rerated Potentials (subject KS)

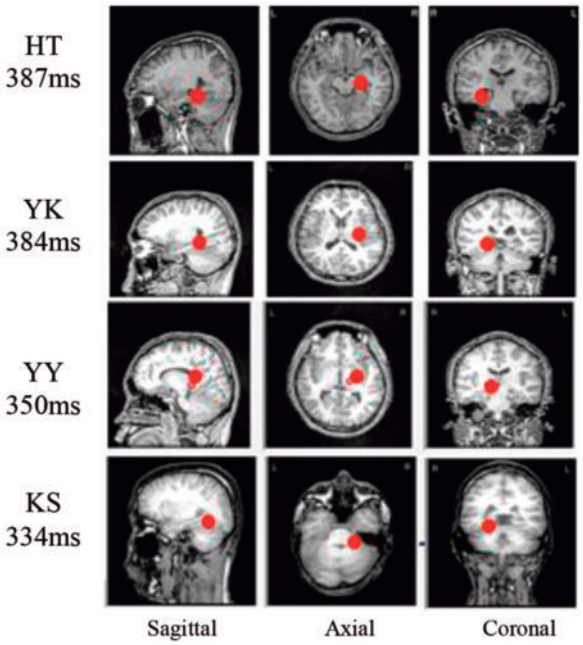

Fig. 4. ECDs localized to the right ParaHip

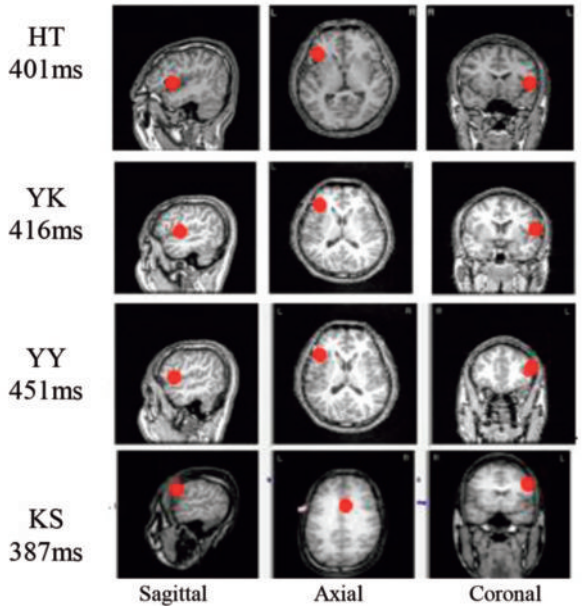

Fig. 5. ECDs localized to the Broca's area

TABLE I. RELATIONSHIP BETWEEN LOCALIZED SOURCE AND ITS LATENCY

subjects	V1	R TE	R ParaHip
YY	88	276	350
KS	119	277	334
	R FuG	R ParaHip	R ParaHip
	361	375	380
	377	380	
	R ParaHip	Broca	L Insula
	386	451	466
		387	
	R ParaHip	R ParaHip	Broca
	485	487	540
	430	470	530
	R FuG	Broca	R AnG
	606	645	652
	585	601	683
	R AnG	R FuG	R Wernicke
	655	678	729
		754	
	R Broca		
	760		
	828		

[ms]

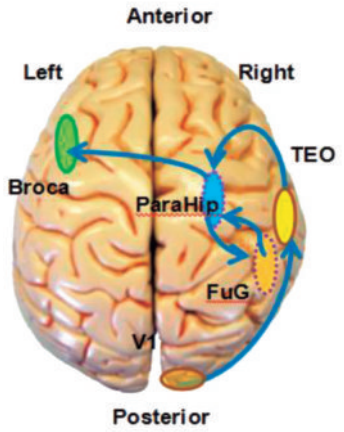

Fig. 6. Spatiotemporal pathway of localized ECDs: Input pathway (YY)
Bold line denotes ECD on surface, Dash line denotes ECD inside

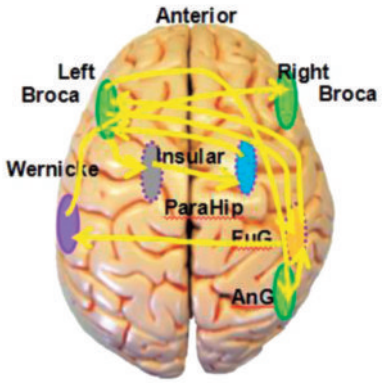

Fig. 7. Spatiotemporal pathway of localized ECDs: Output pathway (YY)

TABLE II. RELATIONSHIP BETWEEN THE RESULT OF PRECEDING RESEARCH AND PRESENT STUDY

line drawing		Preceding research		This study	
		Banana	Persimmon	Cherry	
	subject	HT	YK	YY	KS
1	V1	146	87	88	119
2	R TE	291	316	276	277
3	R ParaHip	387	384	350	334
4	R FuG	391	401	361	377
5	R ParaHip	401	416	375 380 386	380
6	Broca	436	512	451	387
7	L Insula	442	522	466	
8	R ParaHip	508 534	548	485 487	430 470
9	Broca	569		540	530
10	R FuG	584		606	585
11	Broca			645	601
12	R AnG	626		652 655	683
13	R FuG	655		678	754
14	R Wernicke	662	681	729	
15	Broca		711 L	760 R	828

[ms]

three views, one can understand a location of the ECD in a three dimensional space. Localized ECDs by the ECDL method are indicated by dots in these figures.

Above mentioned spatiotemporal pathway accords with so called the ventral pathway which is said to be related with the primitive process of visual recognition. These areas are also related to the integrated process of visual recognition of picture and the recalling of word. Especially, the angular gyrus is said to integrate information of some modalities, so there might have recalled a word already at this stage. On the right inferior temporal white matter, a process progresses from recognition of a picture to recalling of a word.

These processes are done in series or in parallel. The relationship is resumed in TABLE I. Moreover, there is a possibility that these areas are language areas because the subject's dominant language area is considered to be located in the right hemisphere from the precedent research.

According to TABLE I, we found the spatiotemporal pathway of the human brain activities as follows.

(Input pathway) V1 → TE → R ParaHip → R FuG → R ParaHip → Broca

(Output pathway) Broca → L Insula → R ParaHip → Broca → R FuG → R Broca → R AnG → R FuG → R Wernicke → R Broca

In the present study, we have estimated the human brain activities during the subject watching a line drawing of cherry. Some of the present authors have applied the same methodology to EEGs on watching a line drawing of banana (subject HT) and persimmon (subject YK). The results are resumed in TABLE II.

IV. CONCLUSION AND DISCUSSION

We have estimated the human brain activities during the subject watching a line drawing of fruit and recalling its name silently. ECDs were localized to the word generating area and the image recognition area.

We have detected a pathway regarding with the recalling fruit names. By use of ECDL method, ECDs were localized to the right angular gyrus (R AnG), the Broca's area and the Wenicke area. 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.

According to the brain activities of subject YY, we can confirm that most of activity such as the Broca's area and the Wernicke's area are considered to be the language area, these are concentrated on the left cerebral hemisphere. Therefore, the word generation area of YY is predominated in the left hemisphere. On the other hand, the activity on the right Broca's area is also located at 760 ms. From present, the activity on the right hemisphere might be occasionally happened.

Also, the hippocampus, the parahippocampal gyrus and the fusiform gyrus, known as memory area, it is said that language memory in the left hemisphere of the brain mainly, control non-language memory in the right hemisphere mainly. Because the activity with the right parahippocampal gyrus was estimated over multiple times in

present study, some kind of processing in the non-language memory is performed in recalling fruit names, and it is thought that a search, rearranging, maintenance of the memory is always performed it.

Comparing with the precedent study, for an input pathway, both in the precedent study and the present study, the brain activity is found in the parahippocampal gyrus and the fusiform gyrus which are concerned with memory processing. In the output pathway, both in the precedent studies and present study, brain activities are found in the left insula. The insula is said to be related to taste of the food, and it is thought that both cases are related to conscious greed of the taste in fruit shown as stimulus.

On the other hand, in the case of "cherry" and "banana", the activity in the angular gyrus, the Broca's area, and the Wernicke's area are found. The angular gyrus is said to be concerned with a language. The ECDs estimated on the angular gyrus was estimated afterwards on the Wernicke's area. It is thought that integration of input information was carried out in present area. However, in the case of "persimmon", ECD was not localized to the angular gyrus and the Broca's area. We thought that the some factor which is common to "cherry" and "banana" relates here, but "the persimmon" is different from these. However, it was not cleared in present study that which factor is related present fact. The factor may be the difference of "slim fruit" and "round fruit", the different of Japanese style and Western style or, the length of the word. We will try to measure the EEGs and estimate brain activities for other fruits so as to compare these results. Then we will elucidate the areas on the word generation and on the image recognition.

As an application of present study, to the medical field, it may help to determine the cause of a patient's aphasia, and also, to provide a means of new communication to/from the people handicapped. From the clinical lesion studies, it is interesting that our result localized by the ECDL analysis accords with the lesion part that is seen in a patient causing a problem in remembering a word. In addition, it is not known too much on the diachronic change in the clinical studies. Further, as the ability for a name, it is known that there exist differences for a shape. The study may be related to the difference for the shape. And biometric data as the EEG is said to be one of the complex systems that interact strongly non-linear element. Present may help to understand the complex system.

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