Functional MRI activation in repetition task using block and event-related design

Masahiro Abo M.D.PhD[1]
Kazumi Kasahara[2]
Wataru Kakuda M.D[1]
Atushi Senoo PhD[2]

[1]Departments of Rehabilitation Medicine, The Jikei University School of Medicine, Nishi-Shinbashi, Minato-ku, Tokyo, Japan.

[2]Department of Radiological Sciences, Graduate School of Human Health Science, Tokyo Metropolitan University, Higashi-Ogu, Arakawa-ku, Tokyo, Japan

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ABSTRACT

Background: Recently, functional MRI (fMRI) is used for the judgment of the training effect of the aphasia. However, this task is very difficult for fMRI. The purpose of this study is to evaluate fMRI repetition data using block design and event-related design. **Subjects and Methods**: Eleven healthy control men (mean±s.d. 20.4±1.55 years) participated in this study. Block design consists of two different conditions: repetition and rest. Event-related design consists of four different conditions: listening, memorization, speaking and rest. **Results**: We could clearly divide activation areas according to the listening, the memorization and the speaking in event-related design. Activation areas using block design were bigger than those of event-related design. However, tendency is almost the same in both cases. Conclusions: The experimental data corresponds to the clinical treatment in this study. Repetition of the tasks of block design is simple and easily is analyzed. Thus, it has the possibility to be an informative clinical method as an index of aphasia treatment.

INTRODUCTION

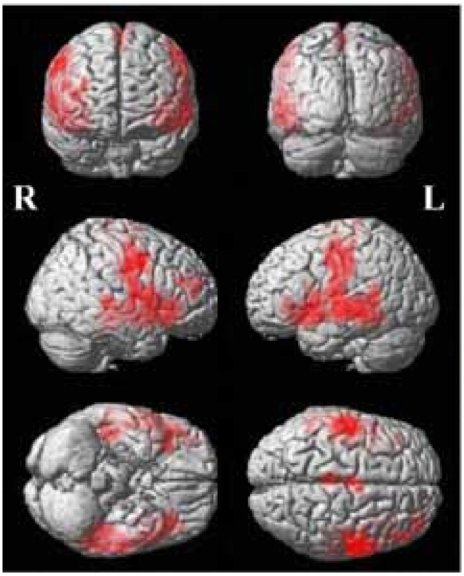
Important advances have been made in brain imaging techniques of functional magnetic resonance imaging (FMRI), as well as in other imaging techniques. Many reports have been published on this topic to date.

The task designs of fMRI generally fall into two main categories: event-related design, and block design. A block design is generally composed of task (stimulation) and rest (rest). Event-related design evaluates the activation of a complicated problem that block design can't analyze.

We compared fMRI findings obtained with a repetitive task in block design in normal subjects with those of two patients with Broca's and Wernicke's aphasia who received speech therapy and showed complete recovery (1). Although repetition is simple, it requires three elements of the listening, the memorization and the speaking in the central process. The simplicity of the task for fMRI warrants its trial in aphasic patients.

The purpose of this study is to evaluate fMRI findings obtained from normal subjects with repetition task using block and event-related design. Activation areas were divided into the listening, the memorization and the

Figure1 *: Three-dimensional fMRI average images of the eleven healthy control men.*
Block design consist of two different conditions (repetition and rest). Activation as repetition were showed.



Repetition (RED color)	X	Y	Z	T-value	Brodmann
Left side					
Middle Temporal Gyrus	-63	-21	3	16.46	21
	-60	-12	-6	14.14	21
	-63	-33	-6	14.11	21
Inferior Frontal Gyrus	-42	39	9	12.23	47
Medial Frontal Gyrus	-3	-6	60	13.55	6
	-54	-3	42	17.93	6
Right side					
Middle Temporal Gyrus	63	-6	-12	7.48	21
	60	-18	-9	7.6	21
Inferior Frontal Gyrus	48	33	0	8.12	47
Middle Frontal Gyrus	51	36	24	8.65	46
Precentral Gyrus	60	0	42	14.07	6
	54	-3	48	13.55	6
	60	-12	42	14.45	6

speaking in event-related design. The differences in activation manifested by each analysis were compared. Our goal is to discuss how to use this informative method as a clinical index of aphasia treatment.

MATERIALS AND METHODS

Subjects: Eleven healthy control men participated in this study. They consisted of healthy right-handed male college students aged 19–22 years (mean±s.d. 20.4±1.55 years).

fMRI:

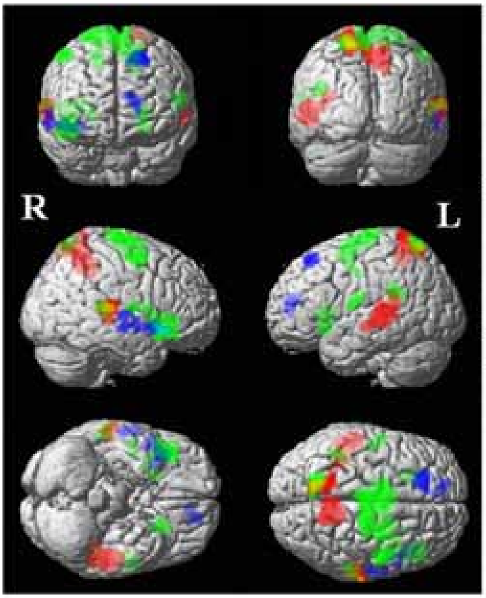
All MRI examinations were performed on a 1.5 T scanner. The head of the subject was immobilized within a circularly polarized head coil. Conventional spin-echo axial-oblique T1-weighted images (TE = 2.4 ms, TR = 26 ms, FOV = 240 mm, matrix size 256×256, slice thickness = 2 mm, covering the whole brain) were obtained parallel to the intercommissural line. These images were later used for co-registration with the functional images for accurate anatomical localization of the activated areas. FMRI was performed using an EPI gradient-echo sequence (TE = 90.5 ms, TR = 5000 ms, FOV = 240 mm, flip angle = 60°, matrix size 128×128, slice thickness = 6 mm, and oriented identical to the anatomical images).

Experiment 1 (block design): Each subject underwent fMRI under two different conditions: repetition and rest. The language comprehension paradigm consisted of 6 cycles of two conditions: (1) rest condition, 1 min; and (2) repeat aloud of the sentence heard though earphones, 1 min. In the repetition task, the auditory stimulus was a series of sentences delivered every 5 seconds binaurally through earphones. Then, the subject was instructed to repeat the word aloud.

Experiment 2 (event-related design): Each subject underwent fMRI under four different conditions: listening, memorization, speaking and rest. The language comprehension paradigm consisted of 30 cycles of four conditions: (1) listening of the sentence heard though earphones, 4sec; (2) memorization, 8sec; (3) repeat aloud of the memorized sentence, 4sec; (4) rest condition, 8sec. In the repetition task, the auditory stimulus was a series of sentences not used experiment 1.

The study protocol was approved by the

Figure2 : *Three-dimensional fMRI average images of the eleven healthy control men.*
Event design consisit of four different conditions (listening, memorization, speaking and rest). Activations as listening, memorization and speaking were showed.



Listening (RED color)	X	Y	Z	T-value	Brodmann
Left side					
Superior Temporal Gyrus	-48	-21	-6	3.86	22
Middle Temporal Gyrus	-54	-33	0	5.05	22
Insula	-36	-45	28	3.65	13
Superior Parietal Lobule	-15	-57	66	3.89	7
Postcentral Gyrus	-18	-51	72	3.76	7
Right side					
Superior Temporal Gyrus	69	-21	9	3.78	42
Superior Parietal Lobule	15	-57	60	3.12	7
Memorization (Blue color)	**X**	**X**	**Y**	**T-value**	**Brodmann**
Left side					
Medial Frontal Gyrus	-15	51	9	7.69	10
Superior Frontal Gyrus	-24	33	54	6.17	8
Right side					
Inferior Frontal Gyrus	48	16	-6	4.52	47
Superior Temporal Gyrus	60	-15	3	4.41	22
Middle Temporal Gyrus	63	-12	-9	3.88	21
Speaking (GREEN color)	**X**	**X**	**Y**	**T-value**	**Brodmann**
Left side					
Superior Parietal Lobule	-18	-63	66	5.55	7
Superior Frontal Gyrus	-30	-6	73	4.88	6
Inferior Frontal Gyrus	-21	18	-9	4.22	47
Superior Temporal Gyrus	-54	-12	18	4.78	22
Postcentral Gyrus	-54	-12	18	4.78	43
Insula	-42	-42	24	5.1	13
Right side					
Superior Frontal Gyrus	30	-6	72	5.3	6
Precentral Gyrus	51	-6	57	5.36	6
Inferior Frontal Gyrus	42	27	-12	5.05	47
Superior Temporal Gyrus	66	-30	12	3.83	42
Superior Temporal Gyrus	48	21	-15	4.66	38
Insula	42	12	0	3.2	13

ethics review committees of participating institutions and a signed consent form was obtained from each subject.

Image analysis:

Motion correction was performed using SPM2 (Welcome Department of Cognitive Neurology, London, UK) implemented in MATLAB (Mathworks Inc., Sherbon, USA). Each of the MRI slices was automatically realigned and reoriented along the bi-commissural line to correct for head movements. Statistical maps were overlaid on the Talairach space 9) and the threshold for activation was set at $p<0.005$ for event-related design and block design.

RESULTS

Three-dimensional images: Figure 1 and 2 show SPM maps of 3D images co-registered with MRI images after normalization of MRI and fMRI data into Talairach space.

Block design (Figure 1, red)

Areas of activation were observed bilaterally in the middle temporal gyrus (BA21) and the inferior frontal gyrus (BA47), the medial frontal gyrus (BA6) of the left hemisphere, the middle frontal gyrus (BA46) and the precentral gyrus (BA6)of the right hemisphere.

Event related design (Figure 2)

Listening: Areas of activation were observed bilaterally in the superior parietal lobule (BA 7), the superior and middle temporal gyrus (BA22), the insula (BA13) and the postcentral gyrus (BA7) of the left hemisphere, in the superior temporal gyrus (BA42) of the right hemisphere. (red color)

Memorization: Areas of activation were observed in the medial frontal gyrus (BA10), the superior frontal gyrus (BA8) of the left hemisphere, the inferior frontal gyrusa(BA47), the superior temporal gyrus (BA22) and the medial tenporal gyrus (BA21). (blue color)

Speaking: Areas of activation were observed bilaterally in the superior frontal gyrus (BA6), and the insula (BA13) and the inferior parietal lobule (BA47), the superior parietal lobule (BA7), the superior temporal gyrus (BA22) and the postcentral gyrus (BA43) of the left hemisphere, the superior temporal gyrus (BA 42, 38) and the precentral gyrus (BA6) of the right hemisphere. (Figure 2, green)

DISCUSSION

Activation areas observed during block analysis were larger than those observed during event analysis.

As we compare two elements of rest and repeat, there is a tendency in block analysis for more activation bilaterally. This is compared with activation areas that were divided into the listening, the memorization and the speaking in event-related design. However, it was thought previously that the tendency was the same for both designs. There are several reports on this (2,3). In other words, activation can be seen in the anterior and posterior superior temporal gyri, the dorsal surface of the superior temporal gyri, the superior temporal sulci and more ventrally in the middle temporal gyri.

Recently, low-frequency repetitive transcranial magnetic stimulation (rTMS), which can suppress neural activity of a selected brain area, has been introduced as a therapeutic tool for stroke patients with hemiplegia or aphasia (4,5). It is crucial to identify areas compensating for impaired language function when rTMS is therapeutically applied for aphasic patients. Adult patients who recover from aphasia after a left-hemisphere stroke have the following three major changes: 1) recovery of damage in left hemisphere language region, 2) peri-lesional reorganization of the left hemisphere, and 3) a significant shift of activation areas into homologous areas of the right hemisphere. Rather than focusing on the importance of each of the above three mechanisms, it may be more appropriate to envisage a system in which the most effective mechanism operates according to the degree of brain damage and patient's status. In other words, we predict that the index of rTMS can be easily obtained if it can be determined which cerebral hemisphere contributes to the recovery of aphasia (6). FMRI of aphasia plays an important role in assessing language function both for focus analysis and network analysis of the whole brain, and can be a useful guide in medical treatment aimed at effective functional recovery. If the data from fMRI cannot be reflected in the clinical treatment, it is insignificant. However, fMRI results from block analysis of repetition task has the possibility to be an informative method as a clinical index of aphasia treatment.

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