Finger Reading by Using Functional Magnetic Resonance Imaging

[1]Chang-Wei Wu, [2]Kai-Hsiang Chuang, Ph.D., [1]Si-Chen Lee, Ph.D., [1]Ching-Po Lin, Ph.D., [1]Jyh-Horng Chen, Ph.D.
[1]Institute of Electrical Engineering, National Taiwan University, Taiwan, ROC
[2]Aviation Physiology Research Laboratory, Air Force Gangshan Hospital, Taiwan, ROC

Abstract

Some people are able to read images or words by using their fingers rather than their eyes. Such capability of finger reading has been studied since 1979. However, the mechanism of the finger-reading phenomenon is still a mystery and remains controversial. To investigate this phenomenon, we provided a preliminary observation of finger reading capability by using functional magnetic resonance imaging (fMRI). In repeated eight experiments, some areas in the brain showed significant activations during finger-reading experiments, especially located in the thalamus, the posterior cingulated and temporal gyrus. These results give some indications to the understanding of the finger-reading phenomenon.

Introduction

The capability of finger reading was studied since 1979. With such ability, one could recognize characters written on a piece of paper by his fingers. Previous studies showed that the mean cerebral blood flow velocity (cBFV) dropped 20% when the subject claimed a screen appeared in his brain, and the alpha waves of brain EEG were well-correlated with the subject's physiological response [1]. It's believed that some regions in the brain are responsible for this exceptional vision, however, only a few evidences were given in previous studies. To investigate the mechanism of the extra-sensory perception ability, we repeated finger-reading experiments by using blood oxygenation level-dependent (BOLD) based functional magnetic resonance imaging (fMRI). Our results show that three areas in the brain (thalamus, posterior cingulated, and temporal gyrus) may play an important role in the finger-reading process.

Materials & Methods

Our subject was a 19-year-old, right-handed female student who was gifted with natural finger-reading ability. Hundreds of target samples were prepared by printing numbers or characters on white pieces of paper before experiment. Samples were folded to such a degree that the pattern could not be seen from outside. One of the folded samples was chosen and put into one opaque bag before finger-reading experiment. Her right hand and the opaque bag were tied tightly with cuffs around her forearm. When the experiment began, the subject touched and felt what the characters or numbers are on the folded sample. The subject would "see" one part of the colored characters suddenly, and then disappeared. Each time the process happened, the subject was asked to press the alarm ball to inform us that she had some vision at that time, and we recorded it as the onset time of her physiological paradigm. The process of finger-reading repeated several times until all the characters were exactly recognized. Results of 8 finger-reading experiments and 2 visual stimulation experiments, using 8-Hz checkerboard with three stimulations and four control periods with 20 seconds per period, were collected. Experiments were performed on a Bruker 3T ParaVision system (Bruker, Ettlingen, Germany) with a birdcage head coil. Images were acquired using gradient-echo echo planar image (EPI) with matrix size of 128 × 128, TE of 35 ms, and TR of 2 sec. The first three experiments (a, b, c) had 5 continuous slices with slice thickness of 5 mm, field of view of 40 × 40 cm^2, and the last five experiments (d, e, f, g, h) had 12 continuous slices with slice thickness of 3 mm, field of view of 25 × 25 cm^2. A plastic belt was tied on the subject's head to prevent the head motion. fMRI maps were obtained using a model-based cross correlation method with a cross correlation threshold of 0.4 in the FACT tool [2] on the Solaris UNIX system.

Results

Our results reproducibly showed that 3 regions had the same fMRI activations. As shown in figure 1, three consistent regions between these eight experiments showed strong correlation. Table 1 showed the results of the eight fMRI experiments. Surprisingly, three regions performed greater percentage of signal change and long delay (about 4 to 6 seconds) than that of the common fMRI study in 3 Tesla MRI. To compare the result of visual stimulation experiments of this subject with normal volunteers', our results showed that the response in her V1 (ΔS/S: 6.62%) had rather large BOLD signal change than that of other people (ΔS/S: 2.92%).

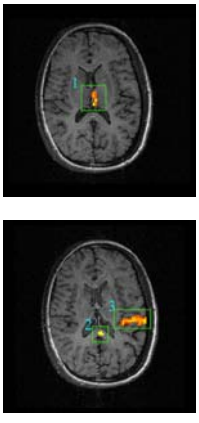

Table 1: The fMRI results of the three consistent activated regions, represented as number of activated pixels and the percentage of signal change.

Experiment	Area 1		Area 2		Area 3	
	Pixel No.	ΔS/S (%)	Pixel No.	ΔS/S (%)	Pixel No.	ΔS/S (%)
A (5 mm)	19	11.43	17	18.82	20	6.29
B (5 mm)	30	13.75	12	12.36	23	8.39
C (5 mm)	11	7.63	6	21.18	6	5.73
D (3 mm)	18	11.77	6	28.90	39	13.55
E (3 mm)	14	15.31	6	18.12	40	10.52
F (3 mm)	14	17.18	11	6.38	40	10.16
G (3 mm)	29	10.65	8	15.10	32	17.31
H (3 mm)	19	13.95	5	26.10	15	18.62
Mean ± SD	**19.25 ± 6.92**	**12.71 ± 2.97**	**8.88 ± 4.16**	**18.37 ± 7.26**	**26.88 ± 12.86**	**11.32 ± 4.80**

Fig 1: The figures showed three consistent activation areas in the 8 finger-reading experiments, marked as Area 1, Area 2, and Area 3. The upper figure represented the location of Area 1, which is around thalamus. The lower figure showed the location of Area 2 and Area 3, which is the posterior cingulate and temporal gyrus respectively.

Conclusions & Discussions

In this study, we explored the extra-sensory perception using fMRI. We located some areas to be relative to the finger-reading process and found their extremely strong BOLD signal changes and long delay. After the Talairach transform, we found the three regions are corresponding to thalamus (dorsal part) [-1 -8 9], the posterior cingulate [0 -35 20] and temporal gyrus [55 -19 9]. One explanation to the strong but delayed signal changes is the sudden increase of cerebral blood flow (CBF), which is positive proportional to BOLD based fMRI, after her perceptional vision response. On the other hand, comparing to the three regions, activations in V1 seemed relatively smaller than others, which may be interfered by some physiological noise. In order to provide more explanations to these

observations, further studies combining BOLD- and CBF-based fMRI technique and EEG detection simultaneously will be used to provide more physiological explanations to this phenomenon.

References

[1]. S.C. Lee et al, Finger-reading: Exploring the Information Field. *The International Journal of Healing and Caring*, Vol. 2, No. 2, May, 2002.

[2]. KH Chuang et al, Image Analysis of Functional Magnetic Resonance Imaging, *Biomed Eng Appl Basis Comm*, 13:248-255, 2001