Reading Handwritten and Printed Text: An fMRI Study

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1. MOTIVATION

We can read handwritten scripts written by different individuals in spite of their idiosyncrasies. Such adaptability is, however, restricted to familiar alphabetical systems. This means that our brains can handle visual diversities in handwritten texts as a result of learning from various types of handwritten texts in the alphabetical systems. In this study, using fMRI, we investigated where in the brain this capability is embedded.

2. METHOD

Subjects:
Fourteen right-handed healthy volunteers (9 males and 5 females) who were native Japanese speakers.

Stimuli Presented to the Subjects:
1. Printed Paragraphs (*Printed*)
2. Handwritten Paragraphs by Writer A (*Handwritten A*)
3. Handwritten Paragraphs by Writer B (*Handwritten B*)

Paragraph images were presented as shown in Figure 1&2.

Analysis:
Images were acquired with the parameters shown in Table 1 and Figure 3. They were motion-corrected, normalized to a standard MNI template, and spatially smoothed (6 mm FWHM) using SPM99[1].

Table 1. Scanning Parameters
A 1.5 T Shimadzu-Marconi scanner was used.

Resolution	3x3x3 mm
TR	6 s
TE	55 ms
FA	90 deg
FoV	192 mm

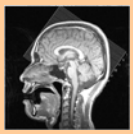

Figure 3. Typical Slice Positions

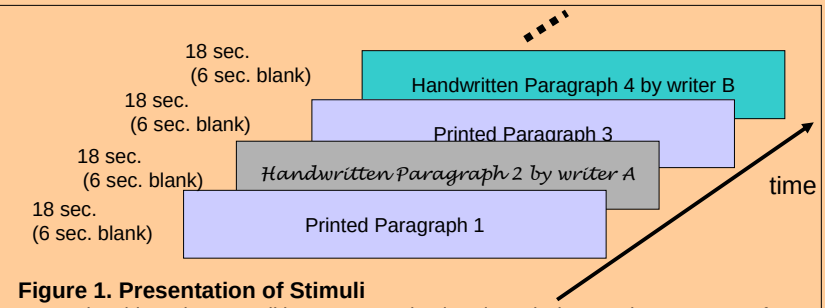

Figure 1. Presentation of Stimuli
For each subject, three conditions were randomly selected whereas the sequence of paragraphs was maintained so that they could be read as a set of documents.

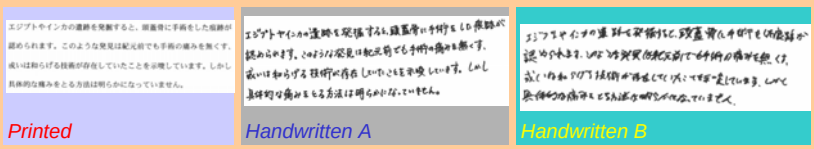

Figure 2. Examples of Stimuli for Three Conditions
These are paragraph images for the three conditions. The contents of these paragraphs are the same. They were scaled so that characters were approximately the same size and presented on a white background. Subjects were asked to evaluate the readabilities of *Handwritten A* and *Handwritten B* between 1 (easily readable) and 5 (unreadable). The result of Wilcoxon Sign test (p<0.01) indicated that *Handwritten B* was harder to read than *Handwritten A*.

3. RESULTS & DISUCSSION

In the occipital lobe, some regions showed consistent activation across tasks. It seems that the left and the right occipito-temporal gyri were activated in a different manner for three conditions. Table 2 and Figure 4 depicts these regions and their major characteristics are summarized below:

- •Left Fusiform Gyrus
- •Left Lingual Gyrus

} Same region was activated for all three conditions. -This region may correspond to the Visual Word Form Area (VWFA) [2]: independent of font size etc.

- •Right Lingual Gyrus

} Different regions were activated for three conditions. -We do not have any concrete explanation for this but we presume that this area may play some role in processing visual diversity of texts as a result of learning.

Table 2. Coordinates of Activated Regions
This table shows axis values of 3 most activated clusters (p<0.001, uncorrected) for three conditions. Indices correspond to the arrows in Figure 4.

	Arrows	Hemisphere	X	Y	Z	T-value
Printed	Red (1)	Right	6	-74	-6	6.69
	Red (2)	Right	24	-76	-10	4.63
	Red (3)	Left	-16	-74	-12	4.45
Handwritten A	Blue (1)	Left	-12	-74	-12	8.45
	Blue (2)	Right	6	-74	-2	5.94
	Blue (3)	Right	18	-58	-8	4.78
Handwritten B	Yellow (1)	Right	34	-52	-8	5.74
	Yellow (2)	Right	12	-68	-6	5.72
	Yellow (3)	Left	-14	-76	-6	5.65

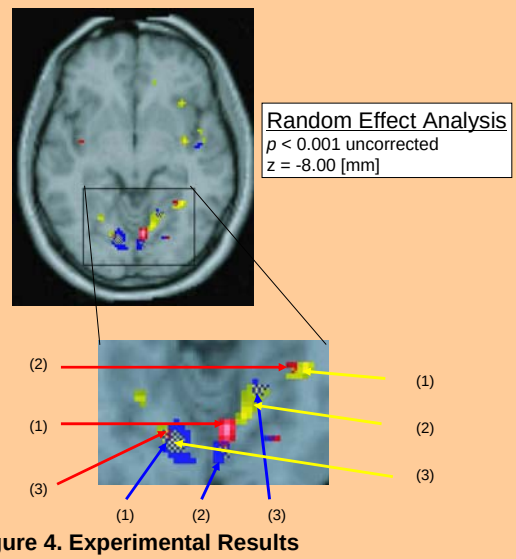

Figure 4. Experimental Results
Red arrows indicate the region activated for *Print*
Blue arrows indicate the region activated for *Handwritten A*
Yellow arrows indicate the region activated for *Handwritten B*

Reference

[1] http://www.fil.ion.ucl.ac.uk/spm/
[2] S. Dehaene et al., NeuroReport, 3(3), pp. 321-325, 2002