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IV. 4. Effect of Kanji and Kana Reading on Cerebral Blood Flow

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Introduction

There are two types of alexia in Japanese patients, i. e. kanji alexia and kana alexia. Presence of two different intra cerebral pathways for processing of syllabolic script and that for morphographic script is believed to be the cause of these clinical discrimination. It is proposed that lesions in left posterior inferior temporal gyrus is responsible for kanji alexia, and left inferior parietal lesion is responsible for kana alexia [1]. We also have reported two cases to support this hypothesis. Each one case of kanji alexia and kana alexia have shown low cerebral metabolic rate for glucose in the lesion located in the left posterior inferior temporal cortex and lesion in left inferior parietal cortex, respectively [2].

In this study, we tried to show these two different pathways in normal Japanese subjects for kanji reading and kana reading by means of cerebral blood flow (CBF) measurements with positron emission tomography. Intravenous injection of 15-O labelled H_2O or bolus inhalation of 15-O labelled CO_2 were used. Preliminary data are shown here. Homology of pathways in kanji and kana reading and pathways for object vision and spatial recognition are discussed.

Materials and methods

Nine Japanese male individuals with an age of between 23 and 57 years old were included for this study. They had a corrected visual acuity of more than 20/25 in each eye and good visual acuity enough to see the video screen in front of him without glasses. Informed consent were obtained from each one of them. The protocol of this study was approved by a committee in Tohoku University.

Subjects were layed in the supine position. Video monitor was prepared in front of the subject 40 cm away from his face. CTI-931 PET scanner were used. Transmission scans for self attenuation correction were obtained. Bolus inhalation of 15-O labelled CO_2 were used for 4 subjects [3]. 15-O labelled H_2O intra venous injection technique were used for 5 subjects[4]. Each emission scan needed 90 seconds of data sampling time and two sets of 7

slices were obtained to cover the whole brain. Standard arterial blood activity curves for bolus CO_2 inhalation or for H_2O injection were applied for subject who did not afford the individual blood curves.

Three physiological visual conditions were given in the random order. Firstly, eyes open controls; both eyes opened subject were kept in the semi-dark room without any display on the video screen. Secondly, kanji reading; kanji visual stimulation was given. Thirdly, hiragana reading; hiragana visual stimulation was given. In kanji visual stimulation, series of three simple words, each one of them are composed of one kanji letter were presented on the screen. Subjects were ordered to read them without pronouncing them one by one, and to choose a word which belongs different groups to the other two words. The first letter was shown at the left, second one was added at the center. The third word was added to them in the right side. Three words were shown altogether for 10 seconds for subject's decision making. No expression of his selection was required to avoid more extended activation involved in motor function. This stimulations were repeated in the pseudo random sequence. This visual stimulation were began 2 minutes before the initiation of each scans and lasted until the end of each scanning. Hiragana visual stimulation were performed in the same fashion but presented in hiragana letters. Five minutes of resting and waiting time for decay of radio activity were taken between each test.

CBF images for each scans were corrected for head positioning so that the horizontal line should be parallel to AC-PC line. Also brain size were normalized. Then, summation images for each three conditions were computerized. Three dimensional surface view were also obtained for these three conditions.

Subtraction images of "kanji-control" and that of "hiragana-control" were generated from each summation images. Also their three dimensional surface displays were prepared. Relative surface activation map for kanji and hiragana readings were obtained by a subtraction between three dimensional CBF displays of "kanji stimulation" and that of "hiragana stimulation".

Results and comments

High blood flow was observed in medial surface of occipital cortex (primary visual cortex), superior temporal gyrus (auditory speech center), and inferior frontal cortex in eyes open control, in kanji reading, and in hiragana reading conditions. (Fig .1)

Blood flow activation in middle frontal cortex (frontal eye field), inferior frontal cortex, anterior cingurate cortex, inferior parietal lobule (including angular gyrus), lateral surface of occipital cortex (visual association ares), and superior temporal gyrus (auditory speech center) were observed bilaterally in kanji and hiragana reading condition compared to eyes open controls. (Fig. 2, Fig. 3)

The areas activated by reading tasks included firstly dorsal and ventral visual structures[5]. Secondly, attention relate area, i. e. anterior cingurate gyrus [6] and thirdly, sensory speech related area, i. e. posterior temporal gyrus.

Specific activation in kanji reading compared to hiragana reading were more distributed in the temporal lobe. And specific activation in kana reading compared to kanji reading were more distributed in frontal lobe, in lateral occipital cortex and in cerebellum. This discrepancy of distribution of CBF activation supports the presence of two different pathways in reading in Japanese language. Nevertheless left inferior temporal cortex in kanji reading and left inferior parietal cortex in hiragana reading were not the only area to be activated. It may be due to the fact that these structures are one of the key chains but not the only ones which is involved in higher visual functions. Our result were in the same trends in the past report of CBF study in reading tasks in Japanese with different ques.

Law and his coworkers have succeeded to show specific activation of supramarginal gyrus in kana reading [7] Momose and his coworkers have reported cases with specific activation of supramarginal gyrus (left > right) with kana word processing[8] Also Law et al. had failed to show statistically significant specific CBF activation of posterior temporal gyrus[7] But they showed significant activation in visual association area. Momose et al. found no specific activation in kanji stimulation [8]

The report of Haxby et al. is remarkable [9] They tried to show a dissociation of object and spatial visual processing pathways in human extrastriate cortex. They reported CBF activation in lateral superior parietal cortex by spatial dot location tasks. They also found CBF activation in occipito temporal cortex by face discrimination. He also mentioned the analogy of visual structures of human and non human primates [5,9] Presence of dorsal visual pathway and ventral visual pathway for spatial and object vision in human, respectively, were first confirmed by PET CBF study in their report.

It is likely that hiragana reading is mainly processed in the dorsal visual pathway differentiated for spatial vision. And kanji reading is mainly processed in the ventral visual pathway differentiated for object vision. Nevertheless instability of our data and other authors data compared to that of Haxby's study may indicate that some words composed of series of hiragana may occasionally be recognized as a set pattern. And in the contrary, word described in kanji may occasionally be recognized by a secondary phonological analysis in Japanese people. Intra cerebral processing of language in other tongue than Japanese may also have the same characters. It is expected to be studied. Farther statistical analysis of our data is also on the way.

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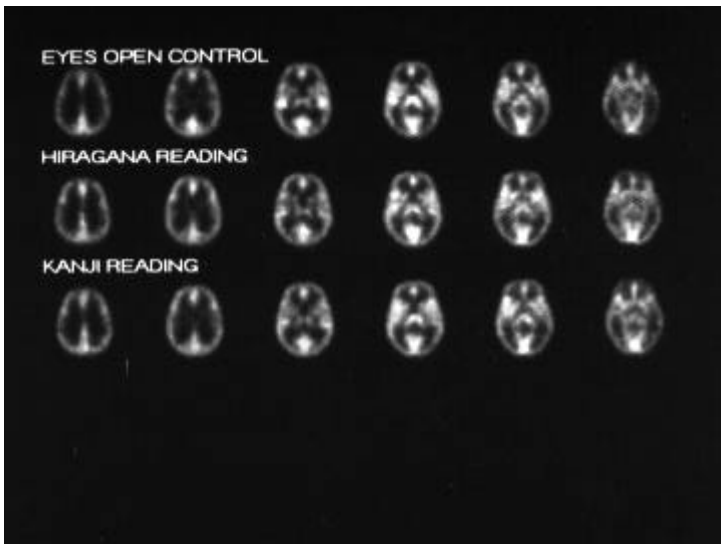
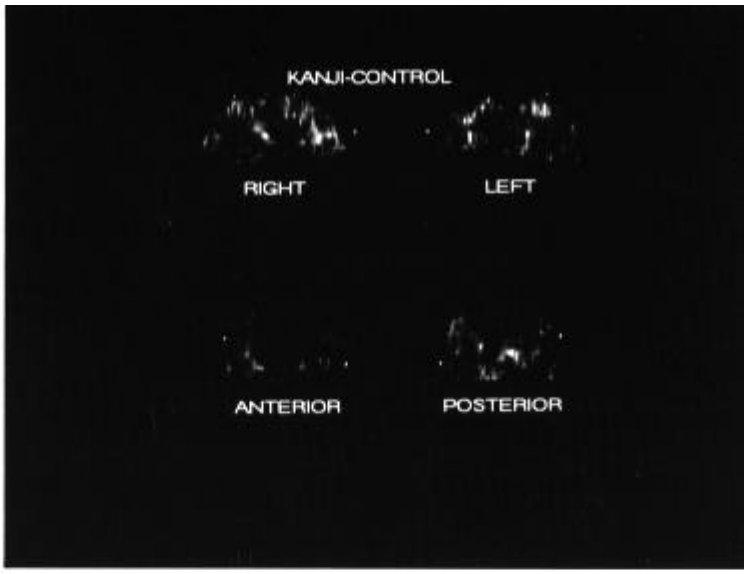


Fig. 1. See text.



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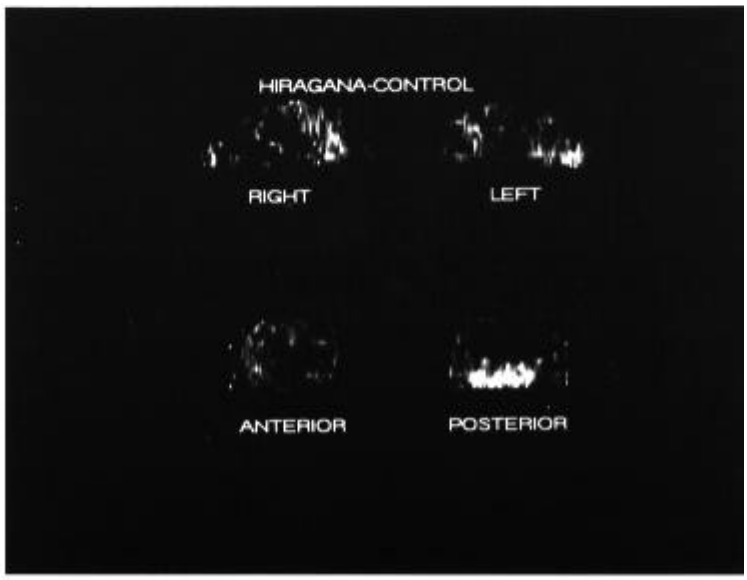

Fig. 3. See text.