Impairment in the Ability to Operate the Internal Representation of Kanji and Kana Characters in Japanese Patients with Pure Agraphia

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It is quite reasonable to assume that at least two different processing stages are involved in normal writing based on the premise that internal representations of letters or visual images of letters exist in long-term memory. The first processing stage is retrieval of visual images of letters in short-term memory before the initiation of writing. The second processing stage is the conversion of this letter image into an appropriate motor pattern which produces writing. Provided these two stages are necessary in the writing processes, agraphia can occur from impairment at any level of these stages. The main purpose of the present study is to investigate the operational ability at this first level, that is the operation of internal representations of kanjki and kana characters in Japanese patients with pure agraphia.

Kanji and kana are the two major transcriptions in the Japanese language, which are directly related to the present study. Kana are phonetic symbols for syllables and kanji are essentially nonphonetic logographic symbols representing lexical morphemes. Kana and kanjki are quite different in terms of their graphical patterns. As shown in the left hand side of Figure 1, kanji are generally much more complex and distinct from one another. They also have certain structural regularities in the way their component units or strokes are combined. Kana comprise 69 symbols each representing 69 moraic units or consonant-vowel type syllables. The number of kanji characters is far greater than the number of kana. The minimal set is approximately 2000 kanji which are adopted for standard use by the Ministry of Education (Sasanuma and Fujimura, 1971, 1972; Fukuzawa, 1982).

	KANJI	KANA
DESK	机	つくえ/tskue/
SHOE	靴	くつ /kuts/
CLOCK	時計	とけい/tokei/

Figure 1. An example of kanji and kana.

METHOD

<u>Subjects</u>. The subjects of the present study were two Japanese pure agraphic cases TS and MY and one normal control subject.

TS was a 72-year-old, right-handed man. He was diagnosed as having an infarction. The CT scan revealed a low density area in the left parietal lobe (Figure 2).

MY was a 65-year-old, right-handed man who had a cerebral hemorrhage. A CT scan revealed a high density area spreading from the superior portion of the left parietal lobe to the deep angular gyrus (Figure 3). The present study was conducted during the period of 23 months post onset for TS and 15 months post onset for MY.

<u>Clinical Testing</u>. Prior to the experiment, the subjects took dictation and reading tests. Oral reading and comprehension of kanji words by TS and MY were almost 100% correct.

Table 1. The results of dictation and reading of TS and MY.

	TS		MY	
	R	L	R	L
Dictation of kanji words	84%* 43/51	88%* 45/51	55%* 28/51	47%* 24/51
Dictation of kana words	76% 39/51	82%* 42/51	68% 35/51	31%* 16/51

R = right hand; L = left hand; % = % correct.
*significant at p < .05.

Dissociation of writing ability in the right and left hands is occasionally reported in cases of pure agraphia. The writing to dictation, therefore, was done in both hands. The writing performance of MY was generally worse than that of TS. The significant differences between these two patients were seen in dictation of kana words in the left hand and dictation of kanji words in both hands.

During these tests, the two agraphic patients took a longer than normal time to write and showed somewhat distorted letters. TS also spoke each kana letter aloud while writing. Figure 4 shows examples of the handwriting and copying of the two patients.


L
R
L
R

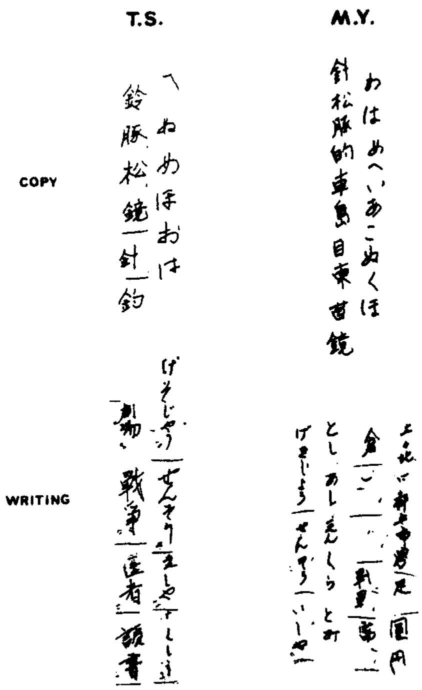

Figure 4. An example of the handwriting and copying of the two cases.

<u>Similarity Judgment</u>. To investigate the operation of the internal graphic representation of kanji and kana, the subjects were required to do a similarity judgment task under two different conditions. The first was a similarity judgment of visually perceived kanji and kana, hereafter referred to as the VP condition. The other was a similarity judgment of internal graphic representation of kanji and kana, hereafter referred to as the IR condition.

In each condition, the subjects performed the three tasks under three different stimulus conditions. Graphically simple kanji (hereafter referred to as simple kanji) and graphically complex kanji (hereafter referred to as complex kanji) were used in the first and second tasks, respectively. Kana were used in the third task.

In the task under the VP condition, a total of 120 triads, each consisting of three characters randomly chosen from each group of 10 characters, were presented one at a time to the subjects. Figure 5 shows an example of triadic comparisons of complex kanji and kana. The subjects were asked to choose the one pair of kanji characters they judged to be most similar of the three pairs in terms of the shapes of the characters.

In the IR condition, the experimenter read three words randomly selected from the ten characters from each group of characters used in the VP condition to the subjects. In the similarity judgment of kanji, the line drawings corresponding to each word were presented to the subjects as material supporting the auditory stimuli. The subjects were asked to recall the visual images of these three kanji characters and to choose the two images of characters they judged to be most similar in terms of shape. Throughout these tasks, the pair which they judged to be most similar at each triadic comparison was recorded.

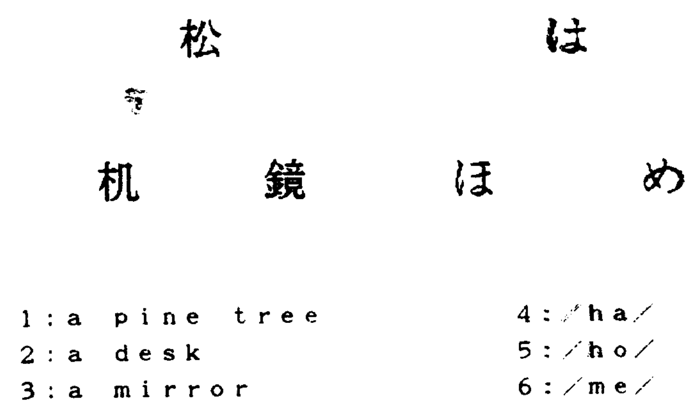

Figure 5. An example of a triadic comparison of kanji and kana in the VP condition.

RESULTS AND DISCUSSION

The subjects' responses to the similarity judgment tasks were analyzed in terms of the frequency with which the subjects chose a particular kanji or kana pair as more similar than the other pairs. These frequencies were converted into similarity matrices and analyzed using nonmetric multi-dimensional scaling MDSCAL. The two- or three-dimensional solutions were obtained by MDSCAL for each task separately (Shepard and Chipman, 1970).

Figure 6 shows the solutions of the normal subject. The characters circled with a solid line indicate the results of similarity judgment under the VP condition and those circled with a dotted line indicate the results of similarity judgment under the IR condition. As Figure 6 shows, graphically similar characters were plotted in the same area under two different conditions.

Figure 7 shows TS's three-dimensional solutions of complex kanji, simple kanji and kana from top to bottom. The results of both simple and complex kanji proved to be generally similar to those of the normal subject. Under both conditions, most of the simple and complex kanji were very well grouped based on their graphic similarity. The solutions obtained under the two different conditions were basically similar.

The solution for the kana characters under the VP condition was also within the normal range. However, the solution under the IR condition was very different from that of the normal subject. These results suggest a functional impairment of TS's ability to operate the internal representation of kana characters while the ability to operate the internal graphic representation of kanji characters remained intact.

Figure 8 shows the results of MY's similarity judgment for simple and complex kanji and kana from top to bottom. Only four groups of similar kanji are seen in both simple and complex kanji under the VP condition. In the IR condition, even fewer groups of similar kanji are seen. In both conditions, the spatial relations within the circled kanji were rather distant.

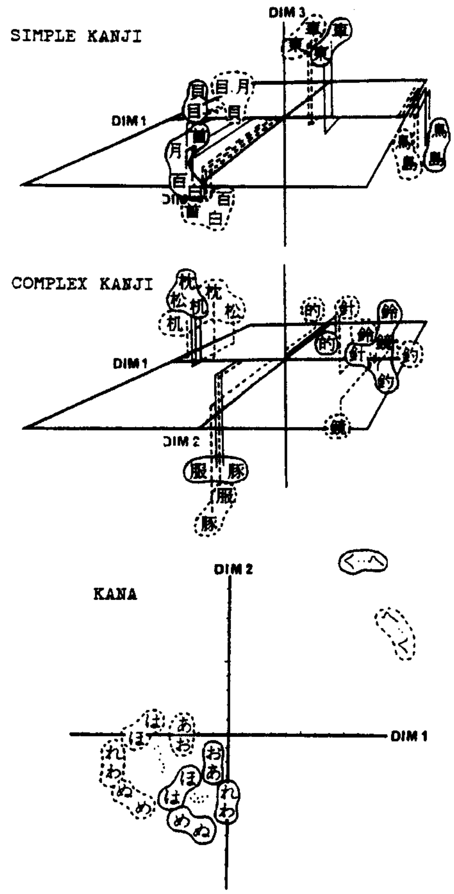

Figure 6. Two- and three-dimensional solutions of simple, complex kanji and kana under two conditions (Normal subject).

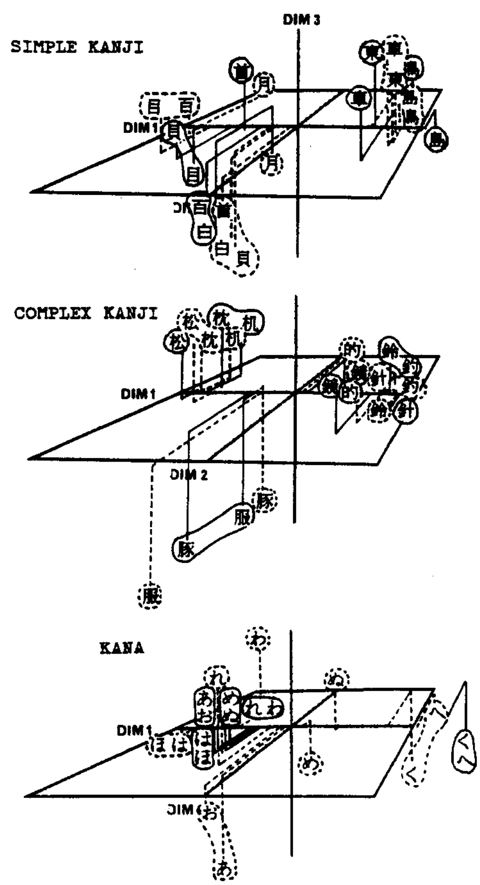

Figure 7. Three-dimensional solutions of simple, complex kanji and kana under two conditions (T.S.).

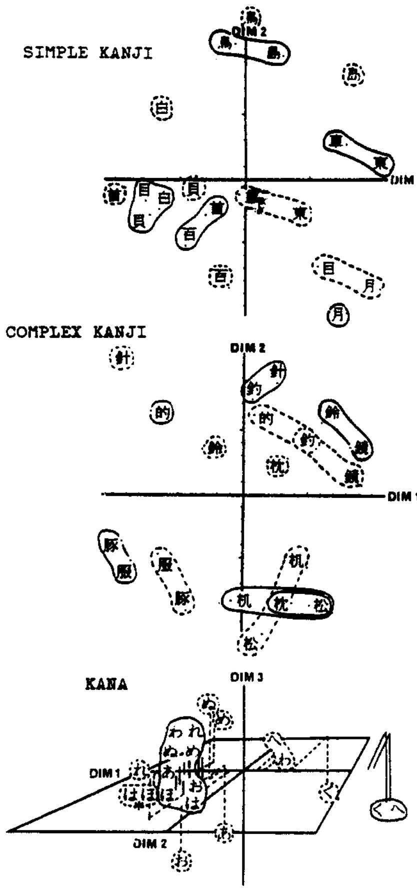

Figure 8. Two- and three-dimensional solutions of simple, complex kanji and kana under two conditions (M.Y.).

The structural correspondence between the two conditions was seen in complex kanji but not in simple kanji. The largest discrepancy between the two different conditions was observed in kana characters. The results obtained under the VP condition showed that the graphically similar kana were plotted very closely together. However, the results under the IR condition did not indicate any interpretable structure except for "ha" and "ho" (See the asterisk in Figure 8.). No correspondence was observed between the solutions obtained under the VP and the IR conditions.

Table 2 shows a summary of the similarity judgment tasks. The - and + signs refer to intactness and impairment, respectively. Several generalizations can be made about the results. (1) The similarity judgments under the VP condition are generally better than those under the IR condition. (2) There was no intrasubject difference between the solutions of simple and complex kanji. (3) The solutions of TS were significantly better than those of MY. (4) The solutions of kanji were generally better than those of kana.

These results suggest that the criteria used by the patients in similarity judgment tasks under two different conditions did not correspond to each other. More specifically, the criteria used under the IR condition was clearly less stable, and in MY it was even abnormal. This is considered to be a manifestation of a functional impairment in the operation of the internal graphic representation of kanji and kana in pure agraphic patients. The finding that there was no significant intrasubject difference between the solution of simple and complex kanji indicate that the degree of agraphic impairment cannot be explained in terms of the graphical complexity of kanji.

Table 2. Summary of similarity judgments.

	Normal		TS		MY	
	VP	IR	VP	IR	VP	IR
Simple Kanji	-	-	-	+-	+-	++
Complex Kanji	-	-	-	+-	+-	++
Kana	-	-	-	+	-	+++

The fact that the dimensional solutions of TS were significantly better than those of MY indicates that MY had far more difficulty in handling the internal graphic representation of letters. This difference between the two solutions clearly corresponds to the difference in the degree of agraphia between the two; i.e., MY's agraphia was more severe than TS's. The discrepancy observed between kanji and kana solutions will be discussed shortly.

Figure 9 shows a simple model of the reading and writing processes. Here we limit our discussion to the process of writing as related to agraphia. In writing to dictation, the auditorily presented word is processed through stage A, and its phonological configuration is analyzed. The internal graphic representation of the word corresponding to the phonological configuration is then accessed at stage C along with its semantic information through the linguistic processing stage B. This graphical representation of the word then elicits its motor command through the processing stage C. The motor command is temporarily stored in STM at the processing stage E and finally writing is executed at stage F.

Theoretically speaking, agraphia can occur from breakdown at any level in these processing stages. The results of clinical testing of the writing of TS and MY eliminated some possibilities. That is, both of these agraphic cases did not show any problem in copying kanji and kana. In copying characters, their stroke orders were always correct and their hand movements in writing were very smooth. This demonstrates these patients' lack of any problem in eliciting motor patterns in writing kanji and kana when the characters are given visually. In our processing model, once the appropriate operation at stage C is completed, the operations at the following stages D through F occur in automatic fashion. Their agraphia appeared only when they were required to write characters based on auditory stimuli. Given the fact that they did not show any other linguistic impairments, it is reasonable to attribute their agraphia to their failure to generate the internal graphic representations of kanji and kana. In this model, the function of processing stage C in connection with stage B is assumed to be impaired.

It is possible to postulate some reasons for the failure to generate visual patterns of kanji and kana under the IR condition in similarity judgment tasks. Plausible reasons are: (1) difficulty in retrieving the graphic representation of the words or letter images, (2) lack of precision in letter images retrieved, (3) inability to internally compare the graphic similarity of several letters. In either case, some malfunction occurs in the operation of the internal representation of letters.

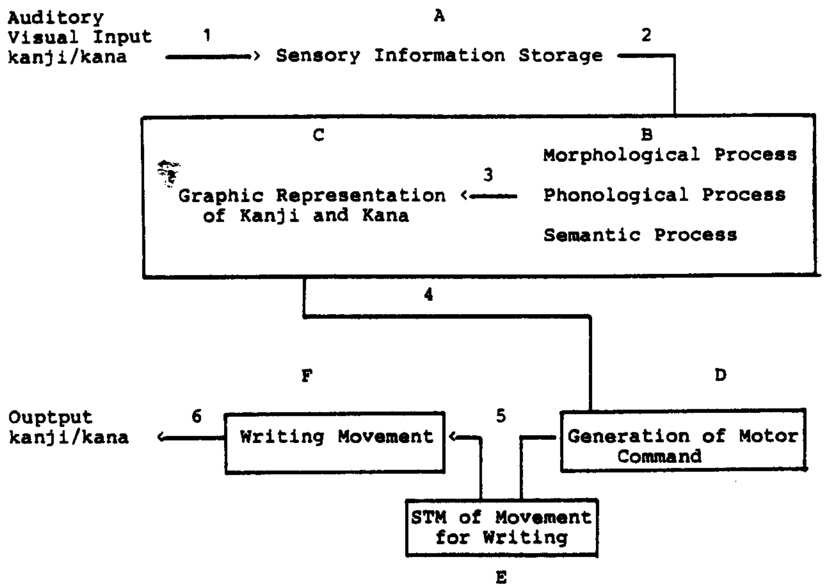

Figure 9. A model of reading and writing processing.

The operation of the internal graphic representations of kanji was significantly better than that of kana in both cases. This may be related to the differential conditions under which kanji and kana were presented. A single Kanji character has a meaning besides its phonological configuration but a single kana has only a phonological configuration. Therefore, the kanji could have more routes to access their internal graphic representations.

Finally, I would like to point out that the application of this kind of methodology to the study of patients with pure agraphia provides information concerning the underlying mechanisms of this disorder. The information will allow clinicians to use more specific approaches in treatment. For example, the operational ability to retrieve letter images may be trained by the use of kinesthetic cues, i.e., having patients trace letter blocks with their eyes closed, which is the reverse process of writing. The effect of this training should be monitored by the level of performance in structural analysis of given characters through internal visualization.

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DISCUSSION

Q: Can you relate or associate the findings of this study in your pure agraphic patients to the studies that have been done on kanji and kana in the speech production system? I am interested in whether or not there is consistency that crosses the production modality.

A: The condition under which kanji were presented is different from that of kana in this study. Single Kana usually do not carry any semantic information but single Kanji convey some semantic information. Therefore, it is practically impossible to compare kanji and kana directly in this study in relation to the results of previous studies done on kanji and kana.

Q: Why do you think that the task you used (making a judgment on perceptual input) is relevant to the process of spelling?

A: What we tried to do was not to relate the perceptual input and spelling but to suggest the relation between the ability to operate internal representations of Kanji and Kana and writing behavior. The reason we used the VP condition was that we knew from our previous studies that there was not a solutional discrepancy between the results of the VP condition and the IR condition in normal subjects and we expected that pure agraphic cases would show some discrepancy between the results obtained under these two conditions.

Q: Did you use the same words in spelling kanji and kana or different words?

A: We basically used the same words for kanji and kana writing. But we also used kana words which are usually written in kana. As far as these kana words are concerned, kanji corresponding to these words were not used for writing.

Q: Did both of these patients have the same visual gestalt ability prior to their insult?

A: We assume that they were within the normal range.

Q: Is it possible that being Japanese and having extensive reading of Kanji as educated people has an effect upon the way in which it was preserved?

A: We don't believe the fact that being Japanese itself would have an effect on the way in which Kanji was preserved. If there is any difference between the way kanji and kana are preserved, it is rather related to the difference between kanji and kana in terms of information processing. But, again, we can't refer to the differential effects of these two characters in this study because of the reasons I mentioned a while ago.

Q: Wouldn't they have learned hiragana before kanji?

A: That is correct. Most of the preschool children learn hiragana before they go to elementary school. They begin to learn very simple kanji at the end of the first year.