KANJI AND KANA PROCESSING IN ALEXIA WITHOUT AGRAPHIA

Sumiko Sasanuma

Alexia without agraphia, or so-called "pure alexia," is considered a rare clinical syndrome produced by a cerebral lesion, consisting of a selective inability to comprehend printed material with retained ability to write both spontaneously and to dictation. The case to be reported here has been judged to have this particular syndrome and has demonstrated, among other things, some unique patterns of impairment in handling kanji and kana characters.

A 64-year old right-handed man, the chairman of a local city assembly, had a sudden cerebrovascular attack on October 9, 1972, followed by severe impairment of reading and a mild right hemiparesis.

Six weeks later, he had a general physical examination at the outpatient clinic of the Tokyo Metropolitan Hospital for the Aged, which revealed nothing remarkable except for mild diabetes mellitus of ten years' standing. The blood pressure was 160/100 mm. Hg and pulse 78. Neurological examination failed to disclose any motor or sensory deficit, except for a slight residue of hemiparesis of the lower right extremity. On the test of visual fields to confrontation, however, there was a right homonymous superior quadrantanopia with macular sparing. There was no other cranial nerve involvement. Eye movements were not affected, either. The findings from EEG and brain isotope scan were somewhat inconclusive as to the exact site of the lesion, but an infraction of the left posterior cerebral artery was suspected.

Assessment of Language Impairment

When he was first seen by the author on the seventh week since onset of his illness, he was alert and cooperative, and gave an accurate account of what had happened to him during the immediate post-onset period. A comprehensive language examination disclosed the following.

Spoken Language

On tests of encoding and decoding spoken messages, the patient performed at an essentially normal level. He did make a small number of errors, however, on tests of picture naming, oral description of situational pictures, and digit pointing span, but a close observation of his behavior during testing gave a strong indication that these errors were due to the presence of a mild degree of visual agnosia. The fact that he obtained a perfect score or performed at a superior level on other tasks that did not use visual materials as the test stimuli (e. g. , tactile naming, word enumeration, and oral repetition of digits), was interpreted as further evidence that his spoken language was intact.

Writing

His performance in spontaneous writing as well as in writing to dictation was superior to the average for his age group. When his spontaneous writing was tested, he faltered once on a kanji word and distorted its shape slightly (泳→氵水). Although he was aware of the error at once and paused to correct it, he was unable to do so. He behaved as if he did not know how to do it. He had no difficulty, however, in moving from one line to the next, nor was his writing slanted abnormally.

A surprising fact was that, in contrast to his fluent handwriting in spontaneous writing and in writing to dictation, he showed a peculiar impairment in copying both kanjis and kanas unless he could recognize them as the specific symbols that he knew. He seemed to be completely at a loss as to how and where to start, and would just stare at the symbol to be copied for as long as a minute or more. If urged to go on, he would start copying it as if it were not a graphic symbol but a strange figure which he had never encountered before, the regular order of strokes being completely lost. He often thus produced quite erroneous figures (Fig. 1b). Sometimes, however, it would happen that while gazing at a stimulus symbol its meaning would come to him all of a sudden and then in a snap his ability to write that symbol in a flowing hand would return, too (Fig. 1a).

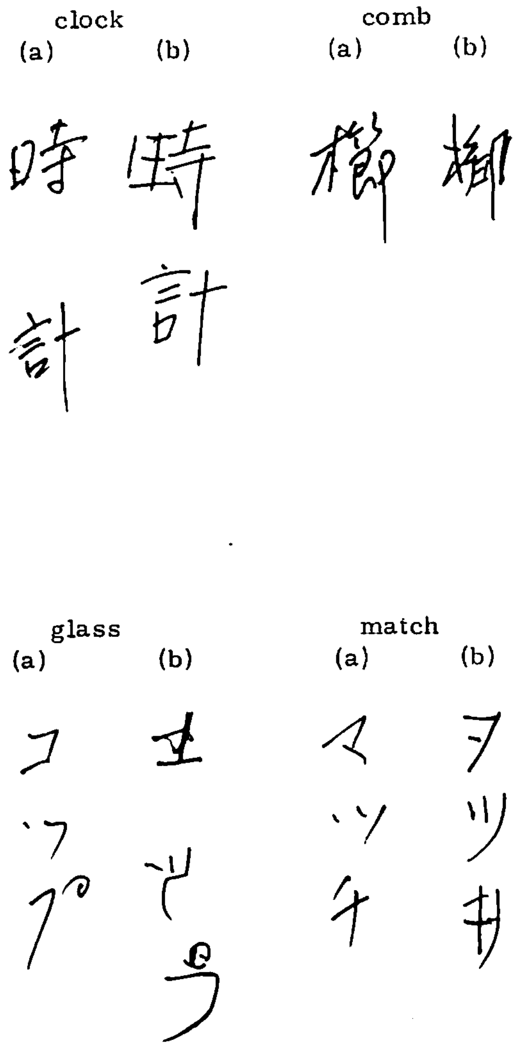

Fig. 1. Kanji and kana words copied by the patient (those under b) as compared to the same words written to dictation (those under a).

Reading

Both oral reading and reading comprehension were severely impaired. There was a tendency for words written in kana signs to give him somewhat greater difficulty than those in kanji characters (13. 5/20 versus 11. 5/20 errors) and for words of two or more characters to cause him more trouble than single character words. The configurational complexity of characters and words, however, did not seem to have any bearing on ease of recognition. He was utterly incapable of reading sentences or paragraphs, including ones which he himself had just written.

His ability to read number symbols, both Arabic and Chinese, was also impaired, although the degree of impairment was slightly less than for kana or kanji.

There was a marked tendency for confusions to occur between symbols of similar configuration, whether they were kanjis, kanas or number symbols (e. g., テ and ラ, わ and ね, 車 and 卓, 枕 and 沈, 5 and 3 and 8). A similar phenomenon took place in regard to 2- and 3-symbol words also, where correct recognition of one or two symbols was followed by erroneous guessing of the remaining one(s), thus leading to a paralexic response (e. g., つばめ tsubame 'swallow' and つぼみ tsubomi 'flower bud', さくら sakura 'cherry' and まくら makura 'pillow', カルタ karuta 'cards' and カメラ kamera 'camera', 手袋 tebukuro 'gloves' and 手帳 techō 'notebook', 冷蔵庫 rēzōko 'refrigerator' and 大蔵省 ōkurashō 'Ministry of Finance').

Another symptom called "visual perseveration" was also present as can be seen in the following example. He misread the character 計 kei as 針 shin, directly after reading the character 金 kin correctly.

No test on musical note reading was performed, since the patient claimed he was musically illiterate.

"Reading" by Nonvisual Stimulation

1. Tactile-Kinesthetic Reading

One of the unique features of his impairment was that he could, with his eyes closed, instantly decipher any and all graphic symbols written on his palm (of either hand) by the examiner with the tip of a pen. The ease and accuracy with which he responded to symbols presented in this manner were impressive in contrast to his great difficulty in recognizing the same symbols visually. These findings, combined with those of his normally retained ability to write, may argue for the integrity of his "visual images of words" (Déjérine, 1892), which can be activated if a non-visual modality (such as the tactile and/or kinesthetic modalities, both of which are involved in the above task) is used to channel the stimuli.

A question arises here as to the specific type of stimulus modality (kinesthetic, tactile or whatever) essential for his comprehension of written material. A series of tasks were devised to seek answers to this question.

Task I. Tactile Reading, in which a set of the rubber stamp graphic symbols of an ordinary kanji or kana printing set (2. 5 cm high) were given to the patient to feel with his fingers (using only one hand at a time) and to guess what they are.

Task II. Modified Tactile-Kinesthetic Reading, in which the examiner randomized the order of strokes of each symbol as she wrote it on the palms of the patient.

Task III. Visual-Kinesthetic Reading, in which the patient was asked to watch the movement of the tip of a pen with which the examiner wrote each symbol in the air, and to guess what it was.

Task IV. Modified Visual-Kinesthetic Reading, in which the examiner randomized the order of the strokes of each symbol as she wrote it in the air.

Task V. Assisted-Kinesthetic Reading, in which the examiner held the patient's right hand in hers and assisted him in writing each symbol in the air with his eyes closed, and had him guess what it was.

Task VI. Modified Assisted-Kinesthetic Reading, in which the examiner randomized the order of the strokes of each symbol as she assisted the patient in writing it.

The results obtained indicate that on Tasks III and V (both of which involved a kinesthetic component of writing movement with regular order of strokes), the patient responded with the same kind of ease and accuracy that he had exhibited in Tactile-Kinesthetic Reading, while on Tasks I, II, IV and VI (which involved only tactile stimulation, or kinesthetic stimulation but with a random order of strokes) his response latencies were much longer (2 to 15 seconds) and he made quite a few errors as well (4/20 - 7/20).

These findings, although preliminary in nature, would seem to be sufficiently suggestive to indicate that what was crucial to his reading comprehension was the kinesthetic (and/or proprioceptive) sensation of the sequential movements involved in the act of writing. In this regard, it is of interest to note that what was required of the patient in Task III (Visual-Kinesthetic Reading) was not the actual motor act of writing himself but visual "tracking" of the tip of the pen with which the examiner made the sequential movements of writing, and even so his recognition of the symbols was perfectly normal.

Mention should be made here of so-called "schreibendes Lesen", defined as a kinesthetic facilitation derived by means of tracing the outline of each symbol with a finger, or of making writing movements in the air. At the time of initial evaluation, the patient did not use this technique, nor could he use it effectively since he had such great difficulty in copying the symbols. As he began to improve in this skill, however, he came to realize the usefulness of the device and by the end of three months he was actively using it whenever he encountered a difficult word.

2. Auditory Reading

The patient was able to comprehend most of the kanji words when the examiner simply named the constituent units of the kanji character(s) used to write the word.[1)] One should note that these names, in their auditory effect, do not ordinarily bear any phonetic similarity to the way the kanji character or word in question is pronounced, nor do they always have a clear semantic association. The phenomenon, therefore, is only superficially similar to the one in which a patient can recognize words when they are spelled aloud by the examiner, as is often the case with the speakers of Indo-European languages. In the latter case what is given to the patient by the examiner would be an auditory stimulus coding the word, while in the former it is a visual configuration of the word(s) as written. (Incidentally, the oral spelling method cannot be used in this way with Japanese patients in prompting them to recall kana words because the names of kanas represent the inherent sound shapes corresponding

1) A kanji character, in general, is made up of several component units arranged in a specific spatial relationship. Each of these units often possesses its own identifying name and can, in most cases, either be a character by itself or in combination with others make up another character. Thus a common custom among Japanese when reminding others how to write a kanji character is to give an oral description of the spatial arrangement of these units (e. g., "A 'tree' ki (木) on the left and a 'city' shi (市) on the right make up a 'persimmon' kaki (柿)").

to the syllables.)

Comparison of Kanji, Kana and Number Symbol Processing

The relative abilities of the same patient in processing *kanjis*, *kanas* and number symbols were followed in some detail for a period of three months after the initial evaluation.

Table 1 shows a breakdown of the stimulus material in terms of the number of items used for each type and length of stimuli. Each item was printed on a white card, the size of the symbol being 2.5 cm high, and vertically aligned for 2- or 3-symbol words and numbers. A total of 150 items was divided into 10 sets of 15 items each consisting of six *kana*, six *kanji* and three number symbol items of three different lengths. High frequency words were selected for all the *kana* and *kanji* items used, except for single *kanas* which, as a rule, represent nonsense syllables rather than meaningful words. The order of 10 sets, as well as the order of 15 items in each set, was randomized each time the sets were presented to the patient to be read. The criterion measure was the response latency of the patient to each item.

Length in. no. of symbols \ Type	Kana	Kanji	Number
1	20	20	10
2	20	20	10
3	20	20	10

Table 1. The stimulus material for reading tasks

The results are summarized in Figure 2, in which the mean response latencies (MRL) are plotted as a function of the length of the stimuli (the number of symbols per item, or NSI). Figure 2a represents the data averaged

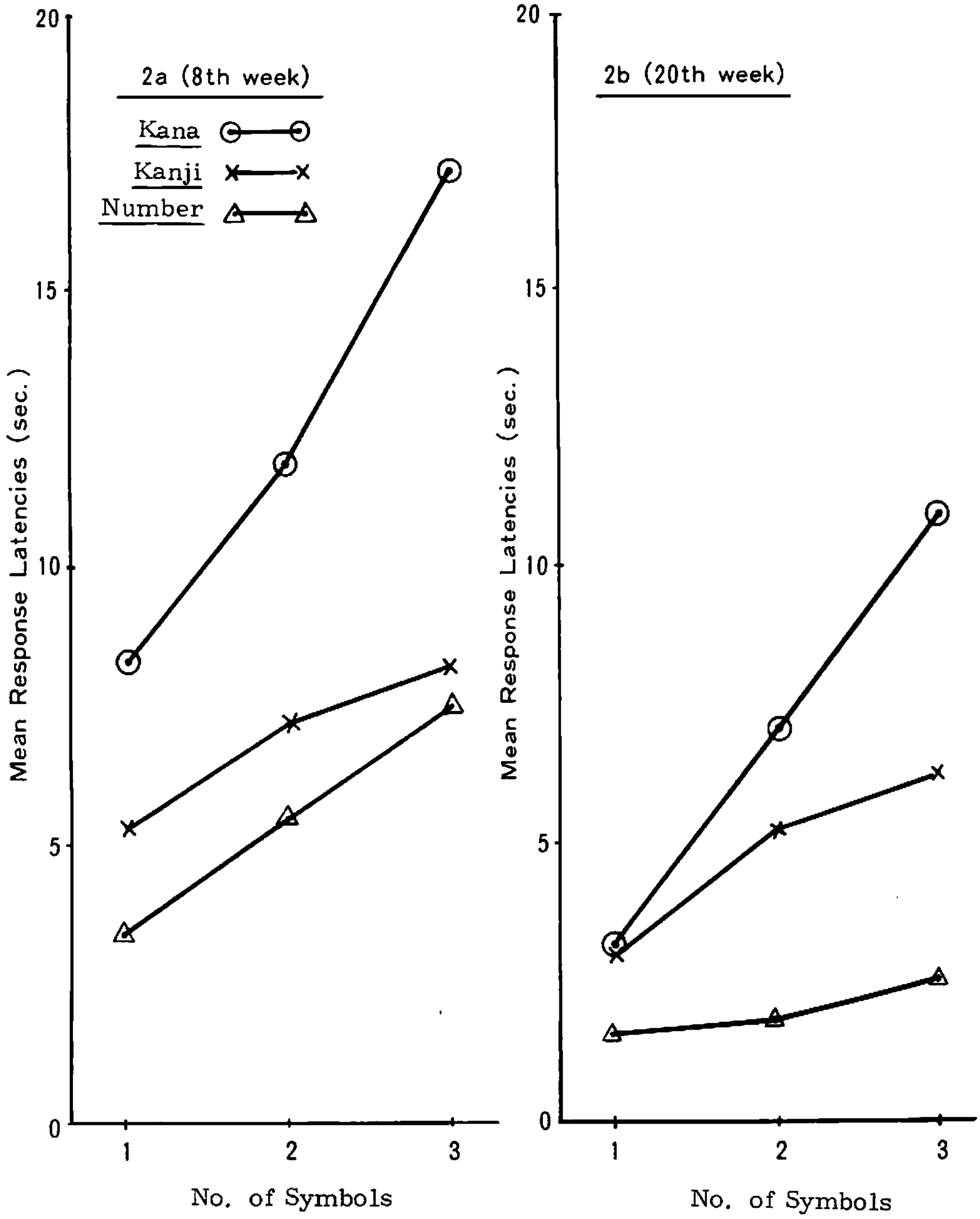

Figure 2. The performance of the patient on kana, kanji and number readings in the 8th and 20th week since onset of illness.

over the first three sessions (8th week) and Figure 2b the last three sessions of the 3-month period (20th week).

It will be seen that over the 3-month period in question a sizable improvement was made for each type of material, while the performance levels for the different types have remained in the same relative positions, viz., kana most difficult, number symbols least difficult, and kanji in between.

Further examination of these results reveals that the length of stimulus material (NSI) has differential effects on different types of material. Most affected are kana items, as indicated in Figure 2a (8th week) by a sharp rise of the slope as a function of the increase in NSI. Almost the same relationship still exists even when the MRL of single kana symbols has reached the same level as that of kanji characters in the 20th week (Figure 2b). On the other hand, for kanji, differences in stimulus length have less effect on the MRL in the 8th as well as the 20th week. The results of an analysis of variance for his performance in the 20th week indicate that the interaction between length and type of stimulus materials is significant.

An explanation for this difference between kana and kanji performance can be sought in the phonetic versus ideographic contrast of the two systems. In the case of kanji, the semantic constraint of each character may put a greater limit on the number of possible combinations of two or more characters as a word, resulting in a much higher predictability of the whole sequence on the basis of partial data, as compared to the kana material. The frequent clinical observations that instantaneous recognition took place for kanji words of three or more characters, while it rarely happened with kana words of comparative length, would seem to be in accord with this explanation.

The performance of the patient on number symbol processing was quite different. In addition to the fact that his overall performance level on number symbols was better than for the other two types in the early stages of his illness, a significant change was observed between the 8th and the 20th weeks, in terms both of the level of MRLs and the gradient of the slope. In other words, as the level of performance on single number symbol items approached that of normals in the 20th week, the length of the stimulus came to have less effect on the MRL, as is shown by the almost horizontal line in Figure 2b, which is also the typical pattern of normal response.

These findings may be explained, as is often done, in terms of the smaller size of vocabulary for number symbols, with the result that they are more thoroughly overlearned, and thus are retained better and relearned earlier in the case of disease. This explanation, however, does not seem to be supported by our findings here that although there are many more kanjis than kanas that are used,[2)] the ability of the patient to read the latter was at first as much, or more, impaired than his ability to read the former. The possibility of an independent mechanism for number symbol processing (different from that for kana or kanji processing), therefore, may be considered to be a more plausible explanation, one which should be explored further in the future.[3)]

Another observation of significance was a great variability of performance from day to day and even from one trial to another in the same session in the early part of the 3-month period. The range of this variability did, however, decrease considerably toward the end of the three months as the improvement began to take place.

Complexity of the Stimulus Configurations

As was mentioned before, the results of our routine diagnostic test revealed that the configurational complexity of the stimulus characters did not seem to have any relationship to the level of performance. In order to investigate this issue further, a part of the data shown in Figure 2b was reanalyzed as follows. The 20 1-character kanji words were divided into two sets according to the level of configurational complexity.[4)] Set 1 consisted of

---

2) Kana signs can be written in two standard versions, hira-gana and katakana: each version has a total of 46 signs, or 69 when those with diacritics are included. In the case of kanjis, on the other hand, a minimal set for basic education includes more than 1850 characters.

3) Another and somewhat more plausible explanation has been presented by some investigators (Déjérine 1892, Symonds 1953, and Geschwind 1965) which states that due to the tendency to count on the fingers in childhood, numbers have strong tactile associations, and thus facilitate recognition of number symbols.

4) Since the configurational complexity of the kanas is on the average far less than that of kanjis, with a much smaller range of variability in complexity, no attempt was made to compare them in this way one with another. Nor did we compare kanas with kanjis in terms of the configurational complexity, because there are other factors differentiating the two types of writing systems, which are evidently more crucial.

10 characters of simple configuration (with a mean of 3.6 strokes per character) and Set 2 the other 10 of complex configuration [5] (with a mean of 11.5 strokes per character), as is shown in Table 2.

Table 2. Simple versus complex kanji characters

Set 1 2 - 5 strokes	人 川 上 大 土 山 木 火 左 本
Set 2 9 - 17strokes	雨 草 旅 南 家 風 窓 森 靴 親

The mean response latencies calculated for each set were 3.3 sec. for Set 1 and 2.7 sec. for Set 2, indicating no significant difference between the sets.

Similar comparisons were made for 2- and 3-character words as well, with similar results for both, i.e., no difference in response latencies between complex versus simple words.

Related Disabilities

A battery of neuropsychological examinations was administered in order to identify the possible presence of visuoperceptive impairments as well as so called parietal lobe signs which have often been known to accompany the syndrome of alexia without agraphia. As will be seen in the brief description of the findings below, the patient in question exhibited mild impairment in various areas of the functions tested.

5) The semantic values of the words in each set were also examined in terms of degree of abstractness and familiarity. No significant difference was found.

Visuoperceptual impairment

As was demonstrated in the naming test and the test of picture description (see page 78), he had some difficulty in recognizing pictures of objects. In the naming task, he picked up each of the picture cards in front of him and turned it around in different directions as if trying to find a perspective that would enable him to identify the object in the picture. Scrutiny of his error responses revealed that he had a tendency to misname a given stimulus picture by giving it the name of something similar to it in gross configuration.

His performance on the test of mixed figures as well as on complex form discrimination was somewhat defective, too. These symptoms, though mild, were persistent, and at the end of the 20th week could still be observed to some extent.

Impairment of color-naming

On the test of color-naming, he made a few errors on neutral colors, i. e., said light brown for pink, purple for light green, and pink for orange when 12 colored sheets were presented to him. He did not have any difficulty, however, in selecting these colors when their names were given to him nor did he show any impairment in handling the color names on a strictly verbal level (i. e., he could state correctly the color of familiar objects, such as cherry blossoms, a young leaf, an orange, etc.). His performance on the Ishihara Test as well as on the Farnsworth-Mansell Test was well within the normal range, indicating that his color-naming difficulty could not be attributed to any demonstrable perceptual disturbance. This mild form of color anomia persisted on and off for a few weeks after the initial evaluation, and then disappeared completely.

Impairment of topographical memory and orientation

Figure 3 illustrates his drawing of a map of Japan. A gross distortion of the overall contour as well as the location of its parts seems to be a clear indication of impairment in topographical memory and orientation. He showed some difficulty in finding his way around in the hospital, too. These symptoms improved considerably during the three-month period of observation but in the 20th week after onset he was still not completely free of them.

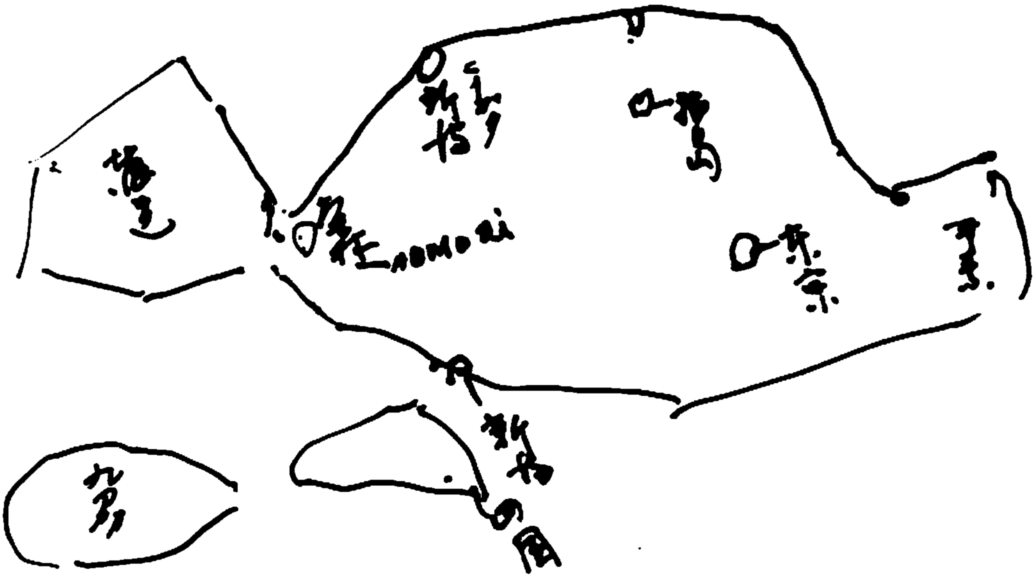

Figure 3. A map of Japan drawn by the patient.

Impairment of visuo-spatial constructions

The possibility of a visuo-spatial impairment was examined on such tests as copying geometric forms, drawing familiar objects, stick construction from memory, and the three-dimensional block construction, as well as on the Bender Gestalt Test and Benton's Visual Retention Test. His scores on these tasks ranged from borderline to mild impairment, suggesting a slight reduction in this aspect of his ability.

Other parietal lobe signs

He did not show any difficulty in right and left discrimination nor did he show signs of finger agnosia. He performed within the normal range on mental calculation. For written calculation, however, his response latencies were abnormally long, and he made some errors, which were suspected to be due to misreading of numbers.

Performance on the Wechsler Adult Intelligence Scale (WAIS)

His performance on the Verbal Subtests was well within the normal range (VIQ:105) while on all of the Performance Subtests he performed at a considerably lower level (PIQ:58). This finding seems to be consistent with the overall picture of his impairment described above.

Remarks

The general symptomatology of the patient reported above fits the description of alexia without agraphia, the underlying neural mechanisms of which can adequately be explained in terms of the disconnection theory of Geschwind.[6)]

There have been some findings, however, which are uniquely related to the use of the kana and kanji systems, and may deserve a brief comment. One of these is the effect of configurational complexity of the characters upon reading performance. As was described before, there was no significant difference in response latencies of the patient between complex versus simple kanji characters. This is a finding which contradicts most of what has been reported in the literature for patients dealing with the letters of alphabets. Further investigation is needed to clarify the reasons for this discrepancy.

Another finding of interest was that the kanji reading of the patient was somewhat less impaired than the kana reading in the initial stage of recovery. The neurophysiological mechanisms underlying this discrepancy remain open to speculation, but the finding would seem to suggest the presence of an inherent difference in the mode of processing of these two types of orthographic symbols. There is evidence indicating that words written in kanji can have a direct access to the semantic representation of the lexical item(s) with no reference to their sound representation, while words in kana may require the mediation of the phonological processor in order to be associated with their

6) The theory says in essence that what constitutes the underlying neural basis for the particular syndrome of alexia without agraphia is a lesion involving the left visual cortex plus the splenium of corpus callosum which results in a disconnection of the intact right visual cortex from the speech regions in the left hemisphere.

meaning (Sasanuma and Fujimura, 1971, 1972). These two different modes of processing, one using a direct graphic strategy and the other an indirect phonetic strategy, might have played an important role in producing the differential performance between kanji and kana readings in this patient also.

Bibliography

Déjérine, J.: Contribution à l'étude anatomopathologique et clinique des différentes variétés de cécité verbale. Mém. Soc. Biol. 4, 61-90, 1892.

Geschwind, N.: Disconnection syndromes in animals and man. Brain, 88, 237-294 and 585-644, 1965.

Sasanuma, S. and O. Fujimura: An analysis of writing errors in Japanese aphasic patients: kanji versus kana words. Cortex, 8, 265-282, 1972.

Sasanuma, S. and O. Fujimura: Selective impairment of phonetic and non-phonetic transcription of words in Japanese aphasic patients: kana versus kanji in visual recognition and writing. Cortex, 7, 1-18, 1971.

Symonds, C. P.: Aphasia, J. Neurol. Neurosug. Psychiat., 16, 1-6, 1953.