Some Contributions of Information Processing Theory to Aphasia Diagnosis

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PROBLEM

Standardized clinical tests have been used extensively in aphasia diagnosis. Some of these clinical tests employ a time scoring system, e.g. they give 3 points if a patient responds to a question correctly within 3 seconds and give 2 points if a patient responds correctly sometime between 3 and 10 seconds. As a result, this procedure yields descriptive information which contributes to clinical classification of patients according to severity of aphasia.

Inherent in this approach, however, is the grouping of aphasic patients who demonstrate a wide range of actual response latencies for a given task. In other words, a reaction time of 0.5 seconds is treated in the same manner as a reaction time of 3 seconds. Similarly, reaction times which are within the next range of scores will result in a different diagnostic classification.

Reaction time can be more clinically meaningful if such tests employ tasks which impose loadings upon different stages of information processing. Utilization of reaction time in this way would then allow examination of the patient's functioning in terms of information processing capacity and assist in differential diagnosis. Such interpretation becomes possible because reaction time is an indicator of which stage is involved in the processing of information.

The present study attempts 1) to compare classification of aphasic patients using scores based on the results of traditional clinical testing and performance on tasks of information processing, and 2) to present a hypothetical model of information processing in aphasic patients.

SUBJECTS

Twenty-six Japanese aphasic patients, including 23 Broca's, one Wernicke's, one conduction and one amnesic aphasic patient were selected to be subjects for this study. All subjects were inpatients at Nanasawa Rehabilitation Hospital in Kanagawa, Japan. All subjects were classified as mildly, moderately or severely aphasic according to results achieved on the Standard Language Test of Aphasia (1975), an instrument designed for Japanese aphasic patients. There were 10 mildly impaired subjects, 11 moderately impaired subjects and five severely impaired subjects. Ten normal control subjects were also selected.

TEST MATERIAL AND PROCEDURE

Nature of Japanese Orthography

The Japanese orthographic system employs a combination of _kanji_ (logographic symbols representing lexical morphemes which are essentially nonphonetic) and _kana_ (phonetic symbols for syllables). _Kanji_ and _kana_ are quite different in terms of graphical patterns as shown in Figure 1.

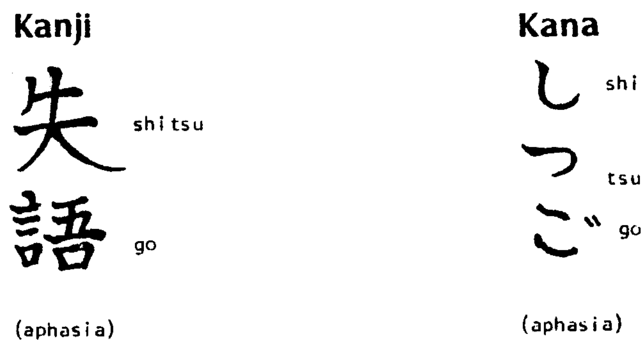

Figure 1. Examples of Kanji and Kana.

Generally, kanji characters are much more complex and distinct from one another than kana and have structural regulations in the way their component units (or strokes) are combined, as seen in Figure 2.

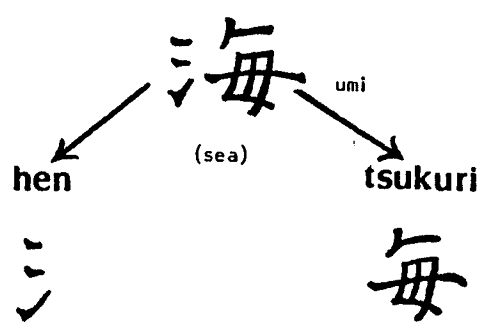

Figure 2. Examples of hen and tsukuri.

More than 80% of kanji characters are composed of the combination of hen (left side of kanji characters which represents the conceptual aspect of kanji) and tsukuri (right side of kanji which represents the phonological aspect of kanji). Thus all the kanji characters which share identical hen refer to the meaning in the same conceptual domain (Sasanuma and Fujinura, 1972).

Task I

Task I was designed to compare the performance of aphasic subjects with different degrees of aphasia severity and normal subjects on a kanji matching task.

An example of kanji stimuli used in Task I is seen in Figure 3. All kanji used for this task were selected using the following consideration: 1) Three different styles of kanji (Mincho type, brush writing and handwriting) were employed. In constructing pairs of kanji stimuli, these three

住　住

提　堤

Figure 3. Example of stimulus pairs used in Task 1.

styles of writing were evenly permuted; 2) Twenty-four kanji pairs were high frequency words and the remaining 24 kanji pairs were low frequency words. Each of the 24 kanji pairs were further divided into two types of 12 pairs each, those with a large number of strokes and those with a small number of strokes. Each of the 12 pairs consisted of six pairs of the same kanji characters and six pairs of different kanji characters.

The size of each kanji character was 3 x 3 cm and the distance between the two characters was 8 cm, subtending a horizontal visual angle of 8.3 degrees. Each subject was shown the 48 pairs of kanji characters and was required to judge whether or not the two kanji were the same. The subject responded yes or no by touching one of the two cards on which yes or no were printed. Reaction time was recorded with a stop watch and correct/incorrect responses were tallied.

Tasks II, III and IV

Tasks II, III and IV were designed to compare the same aphasic and normal subjects on the hen matching tasks with different stimuli. The subjects were instructed to judge whether or not the hen would be identical if the paired stimuli were written in kanji. Stimuli used in Task II were words written in kana, in Task III stimuli were pictures referring to objects, and stimuli used in Task IV were words presented orally. Reaction time was recorded with a stop watch and correct/incorrect responses were tallied.

All 20 pairs of stimulus words used in Tasks II, III, and IV were selected based on the following criteria: 1) stimulus words are high frequency, picturable nouns; 2) none of the words are homonyms; 3) all words, when written in kanji, are composed of hen and tsukuri; and 4) ten stimulus pairs have identical hen while the remaining 10 stimulus pairs have different hen when written in kanji. Figures 4 and 5 are examples of stimulus pairs used for Tasks II and III, respectively.

けむり (ke mu ri) はたけ (ha ta ke) かがみ (ka ga mi) あみ (a mi)

煙 kemuri (smoke) 畑 hatake (field) 鏡 kagami (mirror) 網 ami (net)

Figure 4. Example of stimulus pairs used in Task 2.

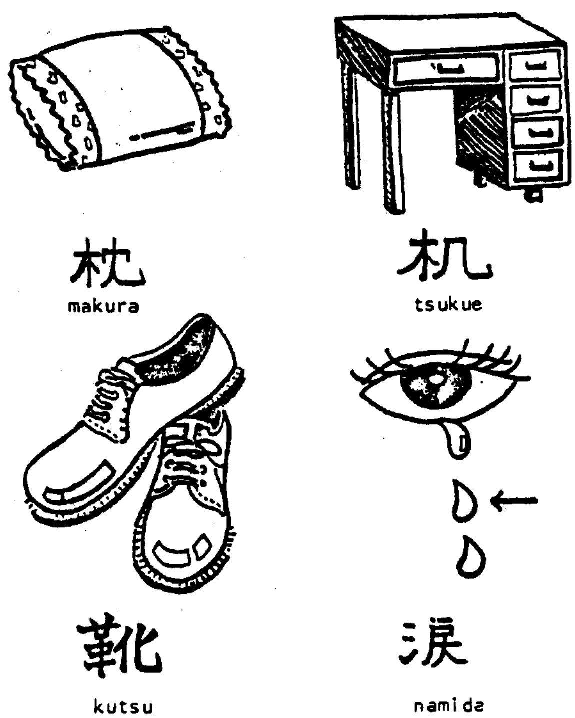

Figure 5. Example of stimulus pairs used in Task 3.

RESULTS

The results of these four tasks, the kanji matching task, the hen matching task using picture stimuli and the hen matching task using auditory stimuli, are summarized in Figure 6.

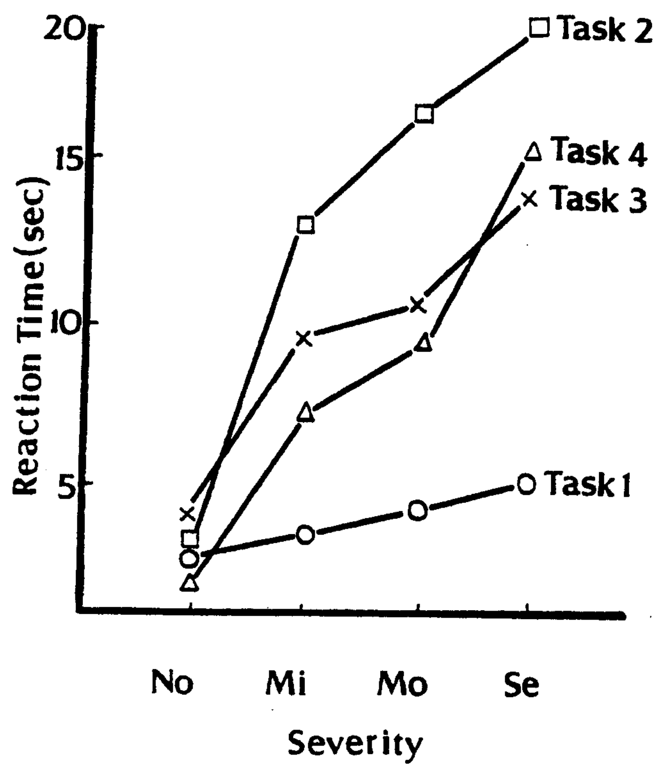

Figure 6. Reaction times on four tasks.

The results of a one-way analysis of variance revealed that reaction times across the three different severity groups were significantly different ($F=5.61$, $df=2$, $p < .05$) in Task I. Multiple comparisons identified significant differences between the moderate and severe, and the mild and severe groups; the difference between the moderate and severe groups was not significant. Differences among reaction times observed in Tasks II, III and IV were not significant. Concerning the percent correct responses, a significant difference was observed in Task IV ($F=3.49$, $df=2$, $p < .05$). The reaction times recorded in the four tasks were significantly different for each task, except for the moderate group between Task III and IV. In aphasic subjects, reaction time increased in the order of Task I (kanji matching task), IV (auditory stimuli), III (picture stimuli) and II (kana stimuli), while the order of reaction time was IV, I, II, and III, in the case of the normal subjects.

DISCUSSION

Norman and Lindsay (1976) and Norman (1977) have suggested that a given piece of visual information is analyzed through a data driven (bottom-up) or a conceptually driven (top-down) process. Any sequence of operations that begins from an element of incoming data is called data driven or bottom-up analysis. On the other hand, conceptually driven or top-down analysis can be defined as process that begins with a highest conceptualization of an object based on prior expectation. In actual processing of information, these two processes operate simultaneously, assisting each other. Since a context which triggers expectations based on past experience produces conceptually driven analysis, processing of information is more effective when conceptually driven analysis is predominant.

Based on Norman and Lindsay's (1976) theory, processing differences observed among the three different severity groups in the first task suggested that the information processing of aphasic patients consists of a combination of conceptually driven and data driven analysis. The more severe the aphasia, the less conceptually driven analysis operates, requiring greater dependence on data driven analysis. Therefore, the more severe group had to scan each graphic part to identify the paired kanji characters. This is the reason that reaction times became longer as severity increased.

In order to support the interpretation of the results of Task I (kanji matching) a supplementary task was conducted. In this supplementary task, Task I was conducted using five American subjects whose kanji reading abilities varied. The purpose of this supplementary task was to investigate the extent to which familiarity with kanji is related to the reaction time needed to identify two kanji characters.

Five American subjects who had resided in the Tokyo area for a few weeks to several months and who knew zero to 700 kanji at the time served as subjects. The same stimulus items used in Task I were presented to the subjects using the tachistoscope.

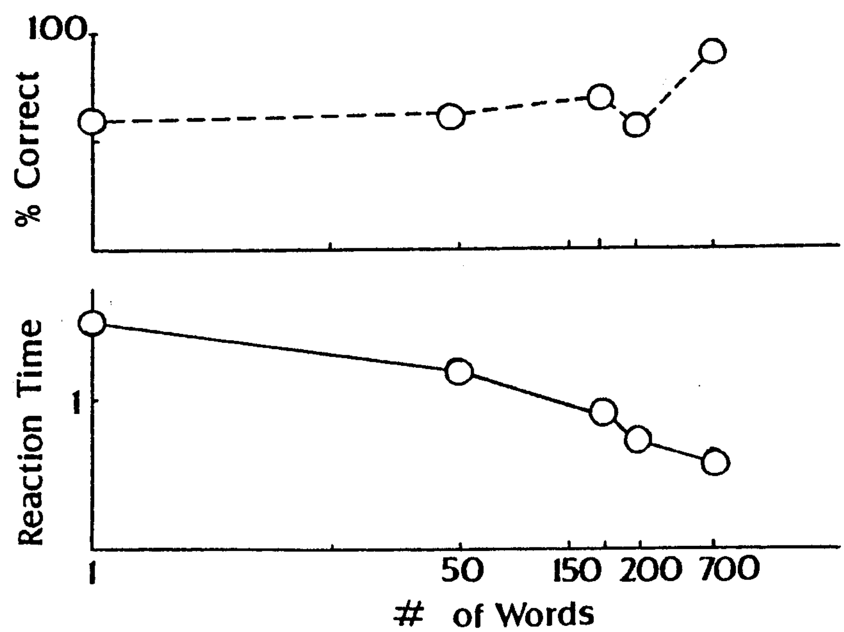

Figure 7. Results of supplementary task.

As shown in Figure 7, reaction time was inversely related to the extent of kanji learned; the percentage of correct responses was positively correlated with the degree of kanji learned except for one subject (the subject who knew approximately 200 kanji). The results were interpreted as supporting the hypothesis of two processing models, i.e., data and conceptually driven analysis. A subject who has not learned any kanji characters must compare each radical of character corresponding to the other character spatially. This processing strategy may be analogous to that of moderate to severe aphasic subjects who are very dependent on data driven analysis. Conversely, the subject who knew about 700 characters performed similarly to Japanese normal subjects, suggesting that the subject used predominantly conceptually driven analysis.

A Model of Visual Information Processing in Japanese Aphasic Patients

A model of visual information processing in aphasic patients was constructed based on the significant differences in Task I and the supplementary study. Furthermore, significant differences among the four different tasks were taken into consideration. The two strategies, conceptually driven analysis and data driven analysis, can be considered in terms of stimulus attributes, i.e., conceptually driven and data driven stimuli. Thus, it may be possible to explain the stimuli used in the study in terms of a combination of these two attributes (hypothesis of visual stimuli).

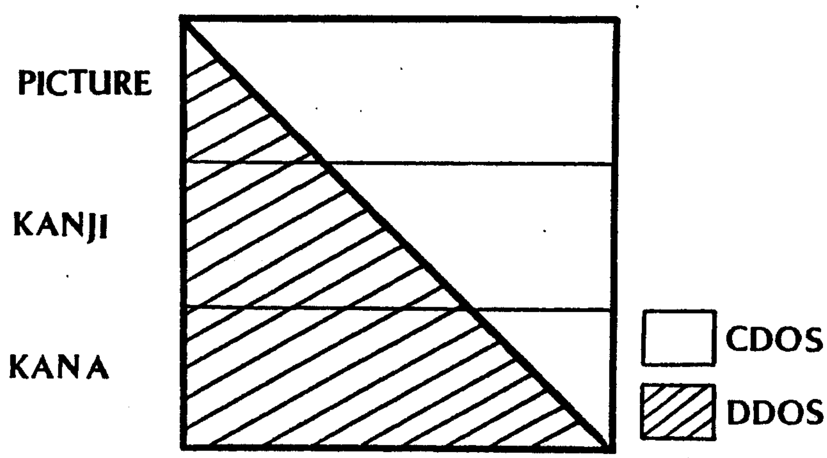

Figure 8. A model of stimulus attributes.

As seen in Figure 8, it is hypothesized that the conceptually driven attribute to data driven attribute ratio can change as the stimuli change from picture stimuli to kana stimuli. The results of Tasks II to IV suggest that the more the stimuli are conceptually driven, the less the reaction time required to process information.

As Lindsay and Norman (1976) and Norman (1977) have suggested, the operation of information processing requires the ability for both conceptually driven and data driven analysis. In the case of normals, the ability for both analyses is available at the level of acquisition of incoming stimuli.

However, in the case of aphasic subjects, as severity increases, subjects become more dependent on data driven analysis. Figure 9 illustrates this. This may explain the significant differences in performances among three aphasic subject groups in Task I.

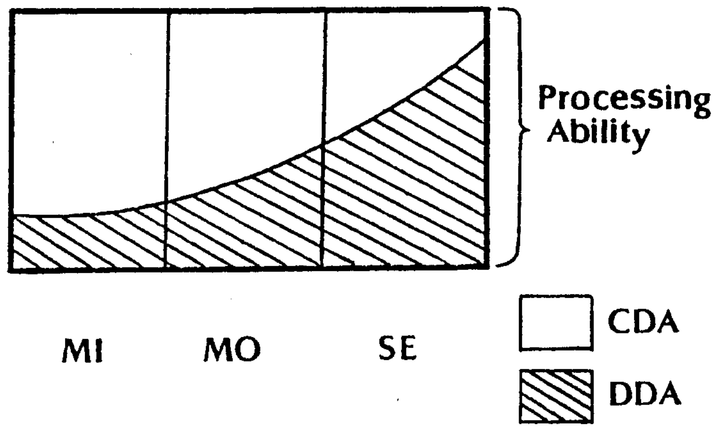

Figure 9. A model of processing ability in aphasia.

Reclassification of Aphasic Subjects on Task Performance

Significant differences were obtained for the reaction times of mildly moderately and severely aphasic subjects on the four tasks except for Tasks III and IV in moderately impaired aphasic subjects. The results suggest that each of the four tasks imposed different load levels on the stages involved in information processing. If the reaction times on the four different tasks reflect aphasic subject's processing abilities, the results suggest that the stages involved in the information processing of Task I and Tasks III and IV, Tasks III and IV and Task II are critically different as seen in Figure 10.

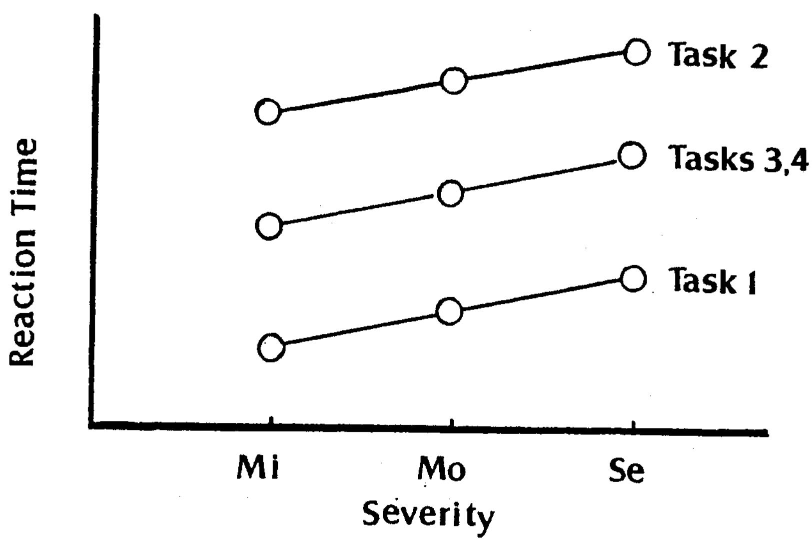

Figure 10. Stage mod

Fourteen different reaction times [2 correct responses (yes and no answer) x 2 choices (yes/no) x 4 different task - 2 uninformative reaction times (negative response in Task I) = 14] for each subject were used as input for factor analysis. Factor scores for each subject calculated from the first three factors were plotted in two dimensional space by combining two factor scores, i.e., factor 1 x factor 2, factor 1 x factor 3 and factor 2 x factor 3. These two dimensional plots were used to reclassify these different groups of aphasic patients (mild, moderate, and severe) by grouping subjects. Reclassification based on the proximity of the data points in the three sets of two dimensional solutions revealed that the original three groups of aphasic subjects can be grouped into five subgroups.

Table 1. Reclassification of patients.

	Severity based on SLTA			
	MI	MO	SE	Total
G 1	4	5	2	11
G 2	2	2	1	5
G 3	1	2		3
G 4	2			2
Other	1	1		2

Table 1 summarizes the relationship between the original classification based on the standardized test and the reclassification based on factor analysis of reaction times. Each group obtained through factor analysis should retain a common functional level of processing capacity among the group members. As Table 1 shows, the mildly impaired group and the moderately impaired group were further divided into four groups excluding one unclassifiable mildly impaired patient. Severely impaired subjects were also divided into two groups. The results indicated that, first, groups 1, 2 and 3 include subjects from two or three levels of severity as determined by the results of the standardized test. This implies that aphasic subjects with different degrees of severity can be classified into one group in terms of their processing abilities. Second, two mildly impaired subjects were relatively isolated from the other groups in the two dimensional solution, suggesting that these two subjects may be qualitatively different from the other mildly impaired subjects. Finally, a mildly impaired and a moderately impaired subject who were not classified as members of any group may demonstrate processing abilities which are different from the rest of the group. Therefore, the creation of new groups suggests that it is possible to further divide a group of aphasic patients with different degrees of severity by their information processing abilities.

Clinical Suggestions

Reclassification of aphasic subjects through factor analysis suggested that data concerning the aphasic subjects' information processing abilities provide additional information to understand the subjects' overall performance level. Although this new classification should be clinically examined in terms of its validity, the clinical implication suggested here is that ordinal clinical tests should employ tasks based on information processing along with the traditional language tests to aid differential diagnosis.

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