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Differences between Conduction Aphasia and Wernicke's Aphasia

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Conduction aphasia and Wernike's aphasia have been differentiated by the degree of auditory language comprehension. We quantitatively compared the speech sound errors of two conduction aphasia patients and three Wernicke's aphasia patients on various language modality tests. All of the patients were Japanese. The two conduction aphasia patients had "conduites d'approche" errors and phonological paraphasia. The patient with mild Wernicke's aphasia made various errors. In the patient with severe Wernicke's aphasia, neologism was observed. Phonological paraphasia in the two conduction aphasia patients seemed to occur when the examinee searched for the target word. They made more errors in vowels than in consonants of target words on the naming and repetition tests. They seemed to search the target word by the correct consonant phoneme and incorrect vocalic phoneme in the table of the Japanese alphabet. The Wernicke's aphasia patients who had severe impairment of auditory comprehension, made more errors in consonants than in vowels of target words. In conclusion, utterance of conduction aphasia and that of Wernicke's aphasia are qualitatively distinct.

Key words : Conduction aphasia, Wernicke's aphasia, Paraphasia

INTRODUCTION

Conduction aphasia and Wernicke's aphasia are clinically characterized by fluent and paraphasic speech. Patients with conduction aphasia have phonological paraphasia and show impairment in repetition, while patients with Wernicke's aphasia have severely deficient language comprehension and use a large volume of meaningless words.

Conduction aphasia and Wernicke's aphasia have been distinguished by the degree of auditory language comprehension. Koyama *et al.* [8] and Furumoto *et al.* [5] reported that the Wernicke's aphasia in some patients developed into conduction aphasia. In these patients, the deficient language comprehension improved within a short period of time and the clinical features changed to those of conduction aphasia.

Blumstein [1] and Burns and Canter [3] reported that there is no difference in the degree of impairment of utterance between those with conduction aphasia and those with Wernicke's aphasia. Thus, the precise pathological difference between these two types of aphasia has not been well elucidated. The purpose of this study was to quantitatively investigate the types of speech sound errors made by patients with conduction aphasia and those with Wernicke's aphasia by comparing utterance aspects, and to clarify the mechanisms of the impairment in each disorder.

SUBJECTS AND METHODS

1) Subjects

This study included two patients with conduction aphasia (Cases 1, 2) and three patients with Wernicke's aphasia (Cases 3, 4, 5), all of whom were Japanese. The characteristics of the patients are shown in table 1. The type and the severity of aphasia in each subject were determined from the results of: (1) the Standard Language Test of Aphasia

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Table 1 Patient characteristics

Case No:	Age/Sex	Diagnosis	Date of onset of the disease	Type of aphasia	WAIS-R PIQ	Token Test		S.S.D.T.		Counting test of syllable	Occupation, etc.
						Hearing	R./U.	Word	Syllable		
1	57yr. Male	C.I.	1995/1/15	Conduction aphasia Mild–moderate	100	75%	98%	100%	100%	100%	College graduate, Architect, Returned to original job in September 1995
2	61yr. Male	C.H.	1996/9/15	Conduction aphasia Mild	83	96%	99%	100%	100%	100%	High school graduate, changed various jobs, accountant at the time of disease
3	63yr. Male	C.I.	1996/3/1	Wernicke's aphasia Mild	93	75%	92%	96%	96%	80%	College graduate, retired from Japanese trading company
4	65yr. Male	C.I.	1996/3/11	Wernicke's aphasia Moderate	88	21%	76%	94%	81%	100%	College graduate, President of private company
5	68yr. Male	C.I.	1996/3/10	Wernicke's aphasia Severe	70	29%	50%	80%	69%	98%	Middle school graduate, Writing Japanese poem, Tanka, as a hobby

C.I., cerebral infarction; C.H., cerebral hemorrhage; WAIS-R, Wechsler Adult Intelligence Scale-Revised; PIQ, performance intelligence quotient; R./U., reading/understanding; S.S.D.T., speech-sound discrimination test

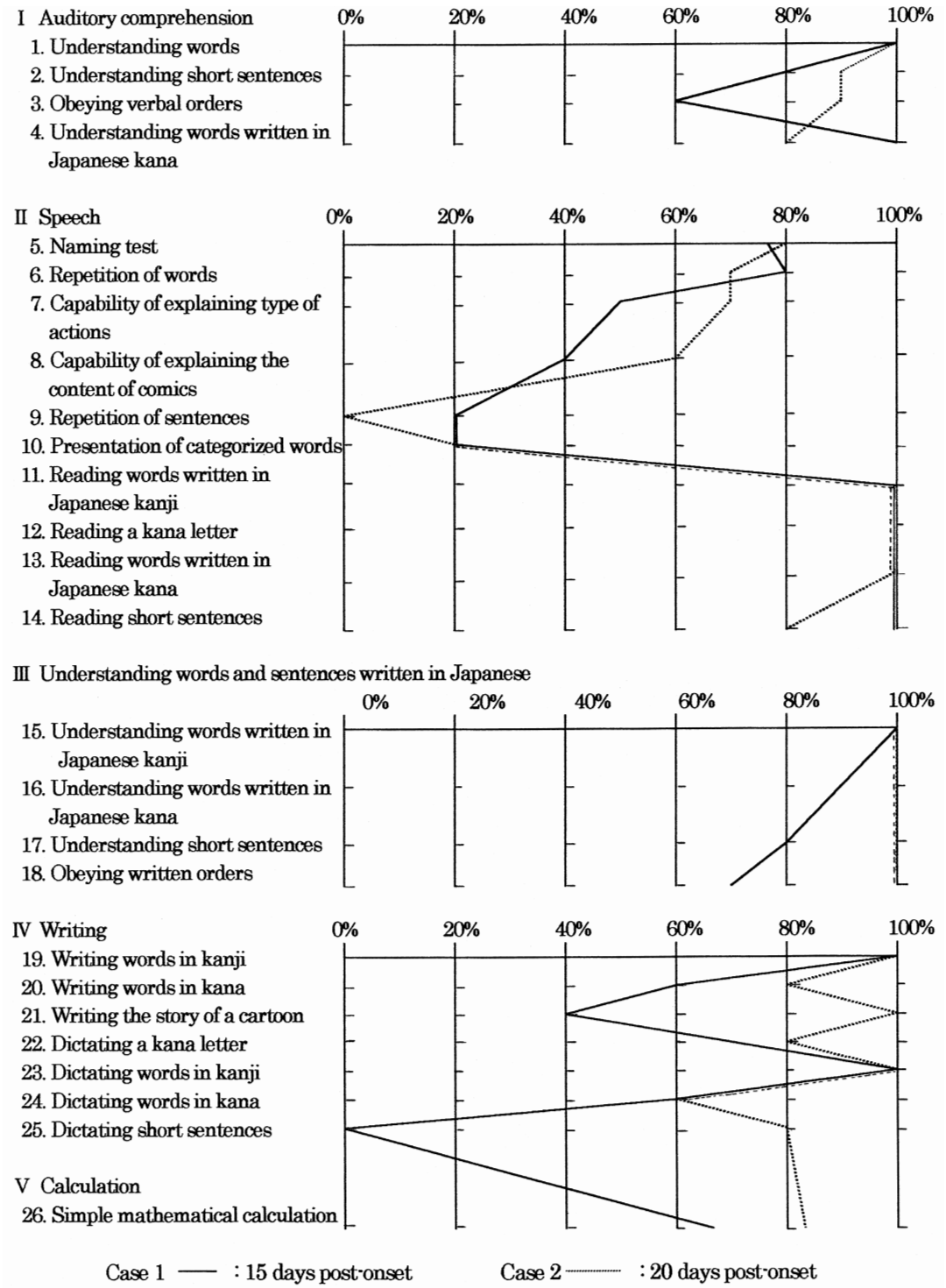

Fig. 1 Results of the Standard Language Test of Aphasia taken by the two patients with conduction aphasia. Case 1 was diagnosed with mild–moderate conduction aphasia, and Case 2 was diagnosed with mild conduction aphasia. The horizontal axis indicates the percentage of correct answers (%).

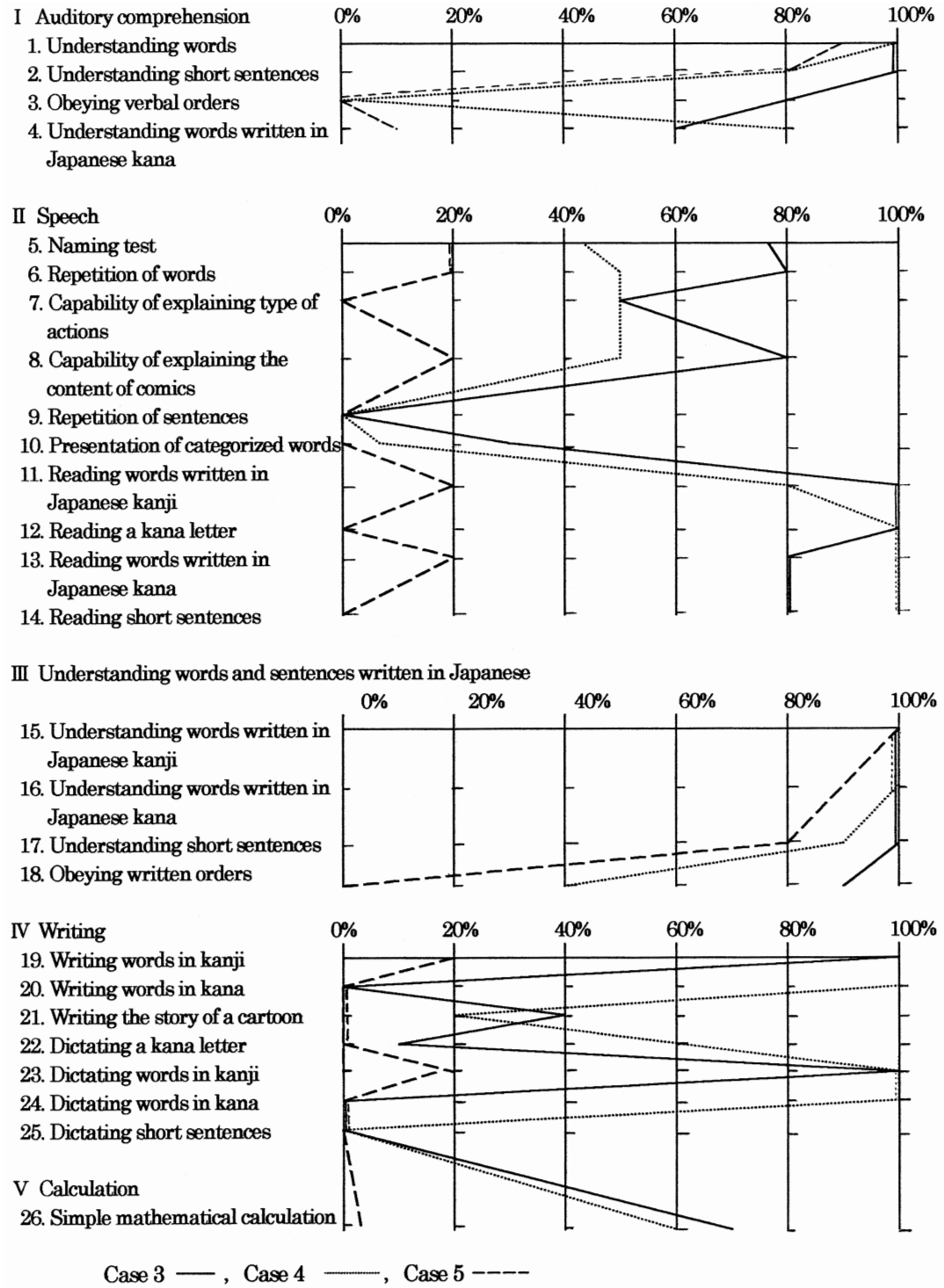

Fig. 2 Results of the Standard Language Test of Aphasia taken by the three patients with Wernicke's aphasia. Cases 3, 4, and 5 were diagnosed with mild, moderate, and severe Wernicke's aphasia, respectively.

(SLTA) [7] (see footnote 1); (2) Token Test [4] (see footnote 2); (3) speech sound discrimination test [12] (see footnote 3); and (4) the counting test of syllable-timed rhythm in Japanese words developed by the authors (see footnote 4). All patients showed fluent and paraphasic speech. Differentiation between conduction aphasia and Wernicke's aphasia was based on language comprehension, speech sound discrimination, and syllable-counting ability, which of all were preserved in conduction aphasia, but not in Wernicke's aphasia. Cases 1 and 2 were evaluated as having mild–moderate and mild conduction aphasia, respectively. Cases 3, 4, and 5 were evaluated as having mild, moderate and severe Wernicke's aphasia, respectively. The results on the SLTA of the two patients with conduction aphasia (Case 1 and 2) are shown in fig. 1, and the results on the SLTA of the three patients with Wernicke's aphasia (Case 3, 4, and 5) are shown in fig. 2. The speech and language ability of Case 5 before the onset of severe Wernicke's aphasia were not impaired, as supported by the fact that he had won a prize for writing a Japanese poem, a tanka. All five subjects were male and right-handed. The intelligence level and activity of daily living (ADL) of all of the subjects were moderately maintained. None had a hearing problem. Although Case 3 had right hemiplegia [Brunnstrom stage [2]: right arm, 5; right fingers, 3; and right leg, 4], he can walk around the house unassisted. All of the tests on the two patients with conduction aphasia were conducted one-to-two months after onset, while all of the tests on the three patients with Wernicke's aphasia were conducted one year after onset. The reason for the delay in testing the patients with Wernicke's aphasia is that it was not until one year after onset that each agreed to testing. An informed consent was obtained from each subject prior to testing. This study was performed in accordance with institutional guidelines for human subjects.

2) Magnetic resonance imaging (MRI) examination

Figure 3 shows the T2-weighted MRI images of the brain of each subject. MRI was performed a minimum of two months after the onset of the disease. In the two patients with conduction aphasia, the areas in the left superior temporal gyrus and supramarginal gyrus showed high signal intensity, while in all three Wernicke's aphasia cases, a relatively large area around the left superior temporal gyrus showed high signal intensity.

3) Methods

Four language modality tests were administered to each subject. The order in which these tests were given was: 1) naming test, 2) repetition test, 3) Japanese Kanji* read aloud test, and 4) Japanese Kana* read aloud test. In the naming test, the repetition test, and the Japanese Kana read aloud test, the total number of target words in each test was 110, consisting of 20 each of one-syllable, two-syllable, three-syllable, four-syllable and five-syllable words (100 words) and ten six-syllable words. In the naming test, the subject was asked to name objects that were drawn on picture cards. In the repetition test,

Footnote 1 In the SLTA, the Kanji test was conducted as follows. The subject is asked to write the names of objects drawn on picture cards, in Kanji. In the Kana test of the SLTA, the subject is asked to write the names of objects drawn on picture cards, in Kana. Date of test: Case 1 took the SLTA on day 15 post-onset; Case 2 took the SLTA on day 20 post-onset; Cases 3–5 took the SLTA 1 year post-onset.

Footnote 2 Twenty "tokens" cut from heavy construction paper are laid out horizontally in four parallel rows. The only requirement this test makes of the patient is the ability to comprehend the token names, and the verbs and prepositions in the instructions, such as "Put the white circle before the blue square." Instructions are given either verbally or visually.

Footnote 3 The speech sound discrimination test consists of two parts. The first part is designed to determine if the subject can distinguish two phonemes read aloud by an examiner, as described in the Speech Therapy Manual (Tokyo Metropolitan Institute of Gerontology 1984). The second test is as follows: A pair of two-syllable words, each containing one of two phonemes [example: kin (gold in Japanese) - gin (silver in Japanese); shiwa (creases in Japanese) - shima (an island in Japanese)], and drawings of each of the two-syllable words are used in each test. The subject is shown the two drawings and is asked to choose the correct drawing when one of the pair of two-syllable words is read aloud by the examiner.

Footnote 4 Counting test of syllable-timed rhythm in a Japanese word. The subject is asked to count the number of syllables in words of one to six syllables given orally by the examiner. The subject is asked to place the same number of Japanese 'go' stones (pieces) as that of syllables. The percentage of correct answers is then calculated.

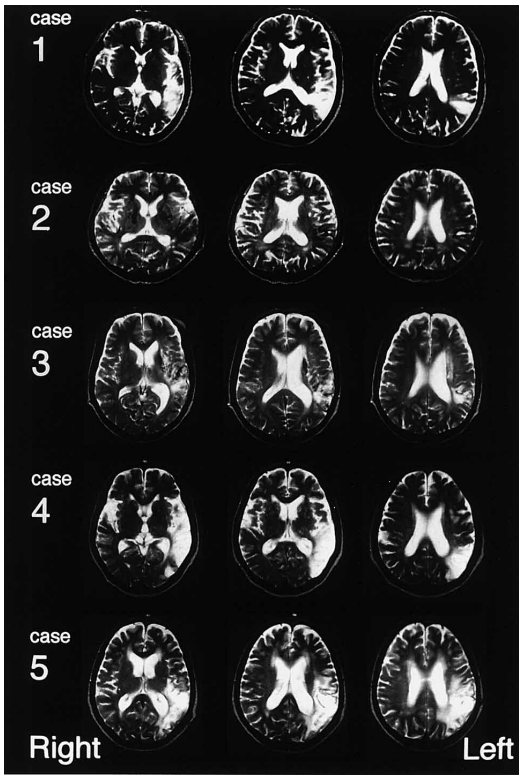

Fig. 3 T2-weighted MRI images of the 5 subjects. Date of examination: Case 1: 1995/4/15, Case 2: 1996/7/11, Case 3: 1996/12/6, Case 5: 1996/11/29.

the subject was asked to repeat words stated orally by the examiner. In the Japanese Kana read aloud test, the subject was asked to read aloud words that were written in Japanese Kana letters on cards. In the Japanese Kanji read aloud test, the subject was asked to read 80 words of one, two, three or four syllables. The 80 words in the Japanese Kanji read aloud test were among those in the Japanese Kana read aloud test, and were written in Japanese Kanji letters. * [Japanese Kana consists of phonetic letters, while Japanese Kanji is a non-phonetic representation of words.]

4) Methods of analyses

The percentage of correct answers, classification of types of errors, and degree of difference between the target word and speech sound error were analyzed as follows.

(1) Percentage of correct answers on language modality tests: An answer was considered to be correct only if the first answer given was correct. The percentage of correct answers on each language modality test was calculated.

(2) Percentage of correct answers on words grouped according to the number of syllables: The percentage of correct answers among target words consisting of one, two, three, four, five, or six syllables, was calculated.

(3) Classification of speech sound errors: Words that were answered incorrectly were classified into one of eight types of errors. Six categories of speech sound error were: (i) verbal paraphasia with semantic substitution (example: patient's answer of 'heart' for the target word 'stomach'); (ii) verbal paraphasia with no relation to the target word; (iii) phonological paraphasia [example: murasara /murasaki (the former has no meaning; the latter means 'purple' in Japanese)]; (iv) conduites d'approche in which the examinee attempts amendment to approach the target word, [example: i.e. 'subu, sabu, sumurai' for 'samurai' (in this case, 'subu...' was amended to say the correct word, 'samurai')]; (v) neologism; and (vi) one-syllable word error. A category for errors on one-syllable words was made because when an examinee's answer for a one-syllable word was wrong, it was difficult to distinguish whether it was due to phonological or verbal paraphasia. The seventh category (vii) was 'others'. Since the number of preservation errors, words originating from a foreign language, and definition errors was small, these were classified as 'others'. 'Impossible to classify' was the eighth category (viii). When an incorrect answer could not be classified into any of the other categories, it was treated as 'impossible to classify'. All speech sound errors including repetition of the same word twice were included in this analysis.

(4) Classification of phonological paraphasia: The third category, phonological paraphasia, was further classified into the following subcategories: (i) addition of a sound, (ii) omission of a sound, (iii) metathesis, or (iv) substitution, according to Monoi *et al.* [10]. The original definition of 'addition of a sound' given by Monoi *et al.* [10] was the addition of a consonant to the vowel area of the target word. In the present study, even when a patient added a sound of more than one syllable, we considered it as (i) rather than a neologism as long as we could guess the target word. Similarly, when

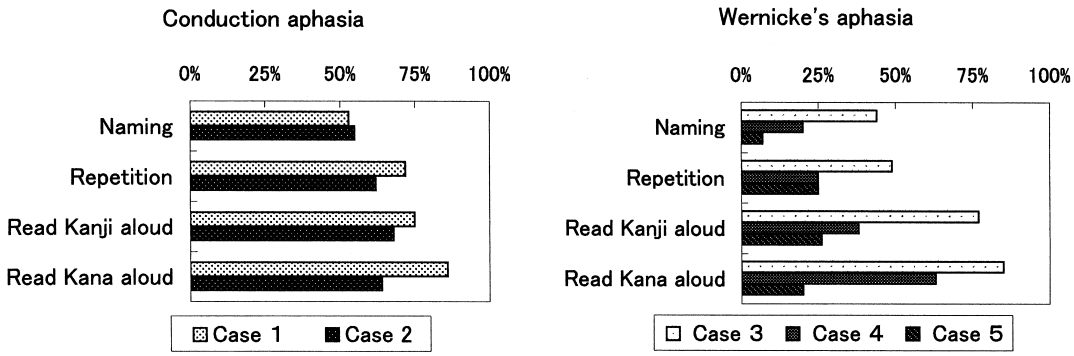

Fig. 4 Percentage of correct answers on the four language modality tests in the 5 patients.

a patient omitted more than one syllable in the consonant area, we considered it as an omission of a sound as long as we could guess the target word. Metathesis was defined to be replacement of a sound in a target word with another sound in the target word [example: nekukai/nekutai (necktie in Japanese)]. Substitution was defined as replacement of a sound by a sound that is not part of the target word [example: hani /hashi (chopsticks in Japanese)].

(5) Metathesis and substitution errors in phonological paraphasia: We determined whether each metathesis or substitution error of phonological paraphasia made by the patient fit into any of the following phonological categories: (i) erroneous sound unit comprised of a correct consonantal phoneme and an incorrect vocalic phoneme (vowel error) [example: sakane/sakana (this means fish in Japanese). This answer has the correct consonantal phoneme and an incorrect vocalic phoneme.]; (ii) erroneous sound unit comprised of an incorrect consonantal phoneme and a correct vocalic phoneme (consonant error) [example: kaizara/haizara (ashtray in Japanese)]; (iii) errors in both the vowel and consonant of a syllable (consonant and vowel error) [example: nokonori/ nokogiri (saw in Japanese)]; (iv) when a sound error was made by the substitution of a consonant for a syllable [example: yukidamma/yukidaruma (snowman in Japanese)], it was considered to be 'impossible to classify', because most Japanese words are formed by a sound system of consonant followed by vowel and substitution by a consonant sounds like the omission of a syllable; (v) when two sounds were dislocated as in the following example [example: kanamiri/kaminari (thunder in Japanese)], it was classified as 'other'.

(6) Errors by substitution of a consonant in phonological paraphasia: To estimate the degree of the difference in the sound of the word spoken by the patient and the target word, we used a distinctive feature framework consisting of nine elements which were consonantal, high, back, low, anterior, coronal, voice, continuant, and strident sounds [10]. For instance, the number of distinctive feature errors in the substitution, (b/p), is 1 because the only difference is voice $+/-$. On the other hand, the difference between (t/k) is $2 + 2 = 4$ because /t/ is consonantal, anterior, and coronal, while /k/ is consonantal, high, and back. For a metathesis error, we did not determine the degree of the difference between the spoken word and the target word because such difference is meaningless, in accordance with the report of Burns and Canter [3].

RESULTS

1) Language modality tests

The score on each language modality test was assessed to be the percentage of correct answers. The two patients with conduction aphasia (Cases 1, 2) had the lowest score on the naming test of approximately 50% (fig. 4). In these two patients, the scores on three of the tests increased in the order of naming, repetition, and read Japanese Kanji aloud tests. The same pattern of scores on these three tests was seen in each of the three patients with Wernicke's aphasia. Among those with Wernicke's aphasia, on each test the test score decreased as the severity of the disease increased. Of the four tests, Cases 1, 3, and 4 had the highest test score on the

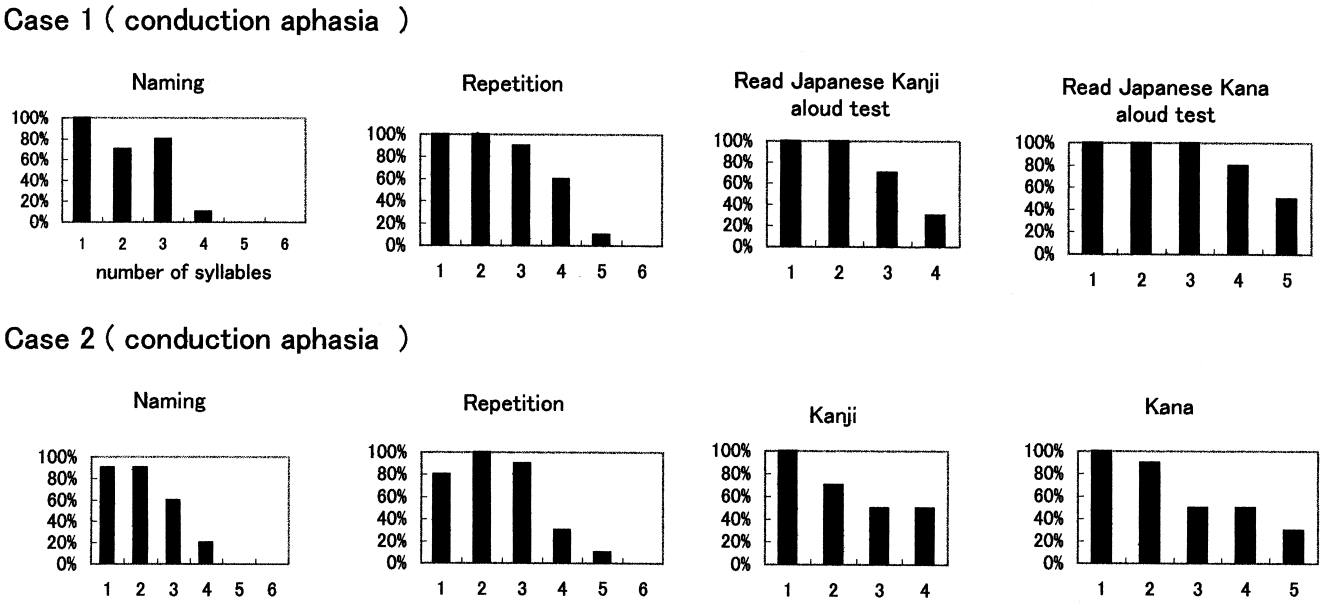

Fig. 5 Percentage of correct answers on each language modality test in the two patients with conduction aphasia according to the number of syllables in the target word.

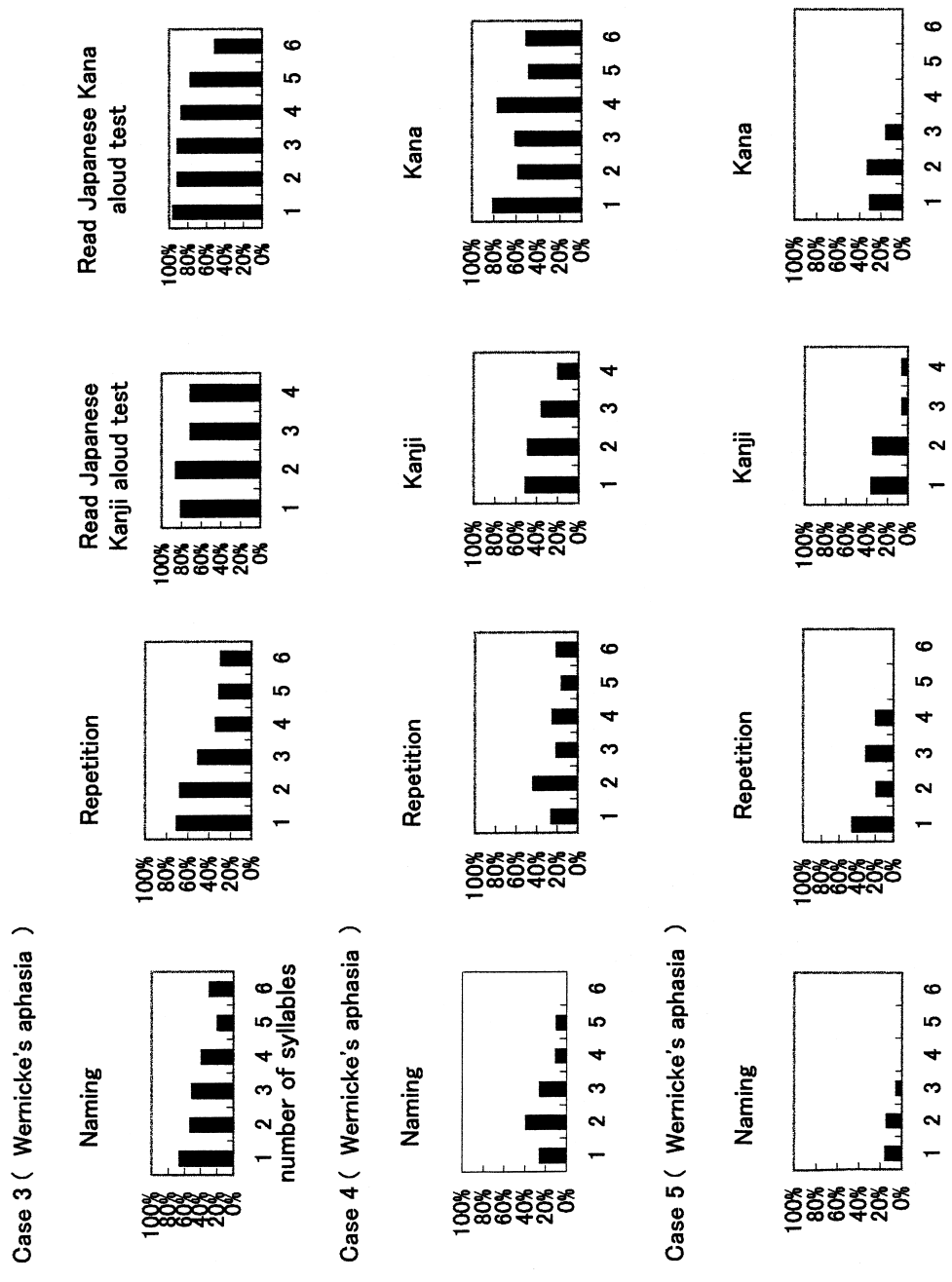

Fig. 6 Percentage of correct answers on each language modality test in the three patients with Wernicke's aphasia according to the number of syllables in the target word.

read Japanese Kana aloud test, while Case 2 had the highest score on the read Japanese Kanji aloud test. In Case 5, the test score increased in the order of naming test, read Japanese Kana aloud test, repetition test, and read Japanese Kanji aloud test.

2) Testing of words with different numbers of syllables

As shown in fig. 5, in the two patients with conduction aphasia, on each of the four language modality tests, the percentage of correct answers generally decreased as the

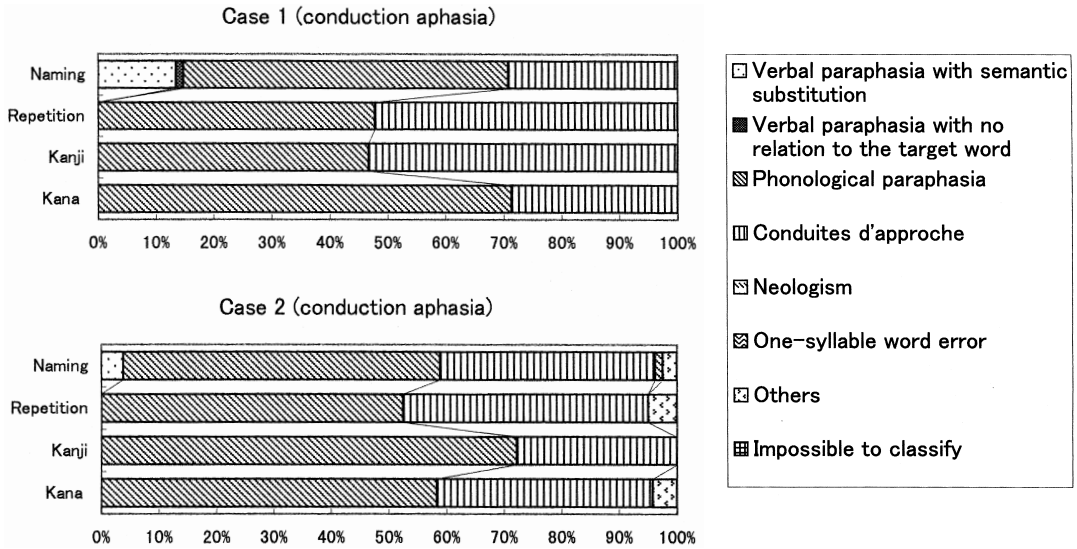

Fig. 7 Classification of the speech sound errors on each language modality test made by the two patients with conduction aphasia. Kanji, read Japanese Kanji aloud test; Kana, read Japanese Kana aloud test.

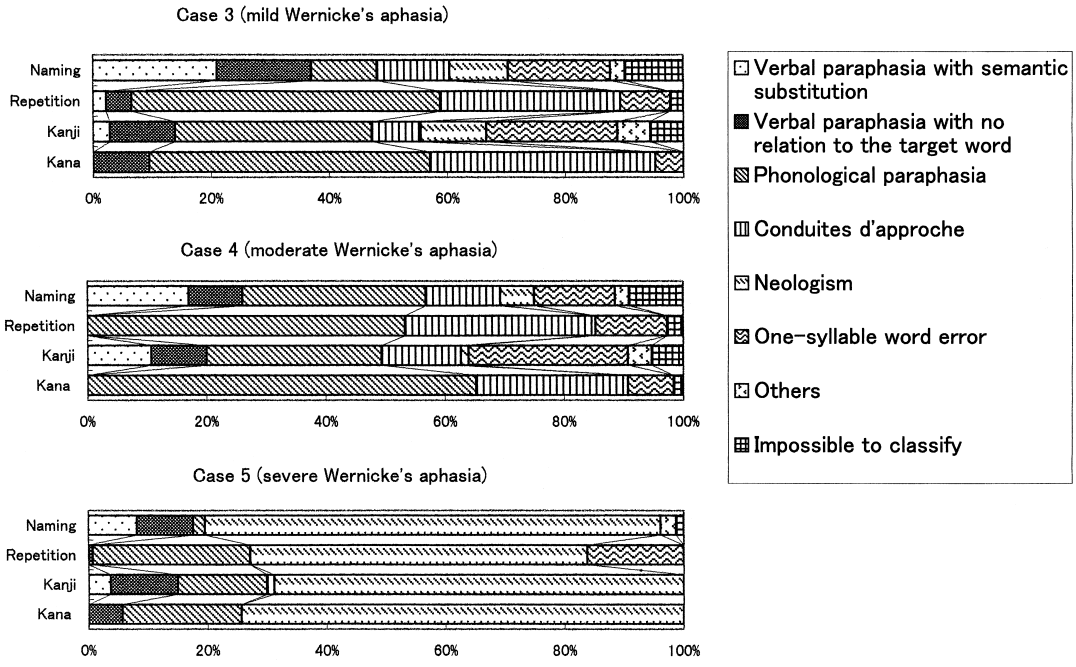

Fig. 8 Classification of the speech sound errors on each language modality test made by the three patients with Wernicke's aphasia. Kanji, read Japanese Kanji aloud test; Kana, read Japanese Kana aloud test.

number of syllables in the target word increased. On the naming test, both Case 1 and Case 2 had a remarkably higher percentage of correct answers on the three-syllable words than on the four-syllable words. On the repetition test of Case 1, the percentage of correct answers on the four-syllable target words was 60%, while the percentage of correct answers on the five-syllable target words was only 10%. In Case 2, the percentage of correct answers on the repetition test of three-syllable target words was 90%, while the percentage of correct answers on the four-syllable target words was only 30%. On the read Japanese Kanji and Kana aloud tests, the percentage of correct answers decreased as the number of syllables increased, although it did not decrease to the extent of that on the naming and repetition tests.

In the patients with Wernicke's aphasia, although the score tended to decrease with an increase in the number of syllables, this was not always the case (fig. 6).

3) Classification of speech sound errors

As shown in fig. 7, more than 80% of the speech sound errors on the four tests made by the two patients with conduction aphasia consisted of phonological paraphasia and conduites d'approche errors. Verbal paraphasia with semantic substitution was demonstrated on the naming test, but it represented only 12% of the errors on the naming test of Case 1 and 3% of the errors of Case 2.

The speech sound errors of the patients with Wernicke's aphasia were more diverse (fig. 8). Case 3 showed mostly phonological paraphasia and conduites d'approche errors of the target word. In this patient, verbal paraphasia with semantic substitution was noted in 21% of the errors on the naming test, the highest percentage of such errors on the naming test among all five subjects. This patient also made other types of errors including errors in single sounds and neologisms on the naming and the read Japanese Kanji aloud tests. Case 4 also made a variety of errors including phonological paraphasia and conduites d'approche errors of the target word. In Case 4, the percentage of semantic substitution errors on both the naming and the read Japanese Kanji aloud tests was 10–20%. In Case 5, most of the errors on each of the four tests (70–80%) were neologisms, and the percentage of phonological paraphasia errors was low.

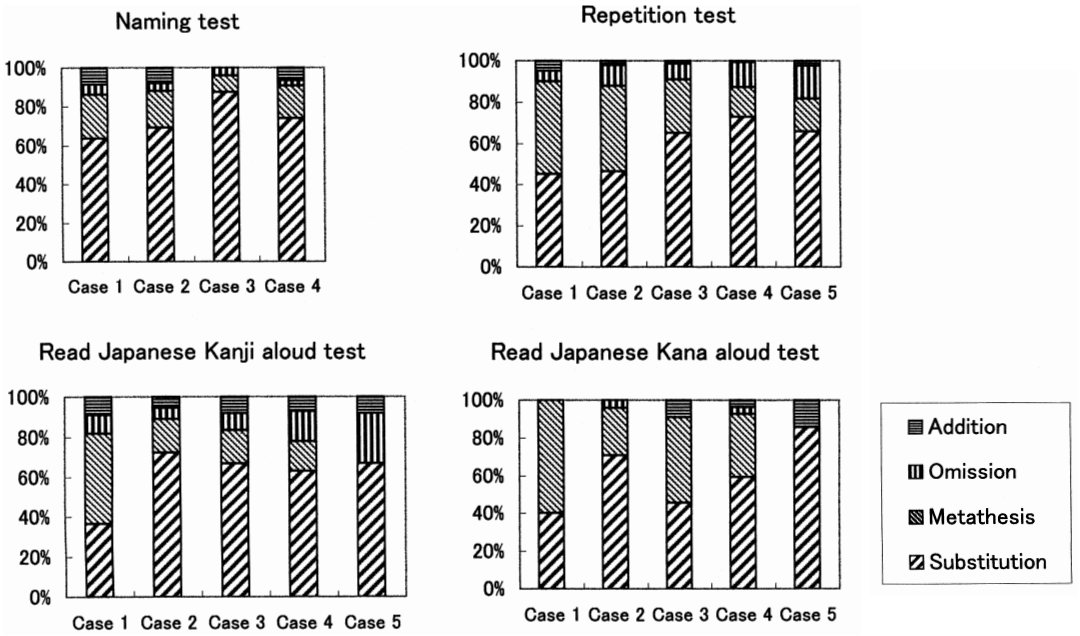

Fig. 9 Classification of the errors of phonological paraphasia. The results of Case 5 on the naming test were omitted from the analysis, because this case made only three errors of phonological paraphasia.

Case 5 also demonstrated verbal paraphasia with semantic substitution, but produced the same word for a particular category regardless of the target word. [In Case 5, the answer for a target word regarding food was always 'Natto' (a Japanese food made of soybeans), and the answer for a target word regarding an animal was always 'dog'.]

4) Classification of phonological paraphasia

On the naming test, since Case 5 made only three errors of phonological paraphasia, this case was excluded from this analysis. As shown in fig. 9, most of the speech sound errors of phonological paraphasia in Cases 1–4 were substitution. On the repetition test, the two patients with conduction aphasia

Table 2 Frequency of vowel and consonant errors (%)

Naming test	Case 1	Case 2	Case 3	Case 4	Case 5
vowel errors	13 (33.3)	20 (29.9)	2 (8.7)	7 (10.4)	1 (33.3)
V+C errors	6 (15.4)	10 (14.9)	10 (43.5)	7 (10.4)	1 (33.3)
Consonant errors	19 (48.7)	36 (53.7)	11 (47.8)	51 (76.2)	1 (33.3)
Others	0	0	0	0	0
Unable to classify	1 (2.6)	1 (1.5)	0	2 (3.0)	0
Total	39 (100.0)	67 (100.0)	23 (100.0)	67 (100.0)	3 (100.0)

Repetition test	Case 1	Case 2	Case 3	Case 4	Case 5
Vowel errors	7 (38.9)	8 (22.2)	12 (20.0)	6 (5.2)	4 (12.9)
V+C errors	5 (22.2)	7 (19.4)	6 (10.0)	5 (4.4)	4 (12.9)
Consonant errors	7 (38.9)	21 (58.4)	42 (70.0)	101 (88.6)	21 (67.7)
Others	0	0	0	1 (0.9)	2 (6.5)
Unable to classify	0	0	0	1 (0.9)	0
Total	18 (100.0)	36 (100.0)	60 (100.0)	114 (100.0)	31 (100.0)

Read Japanese Kanji aloud test	Case 1	Case 2	Case 3	Case 4	Case 5
Vowel errors	4 (44.4)	2 (12.5)	4 (40.0)	2 (9.5)	1 (12.5)
V+C errors	5 (55.5)	6 (37.5)	1 (10.0)	2 (9.5)	0
Consonant errors	0	8 (50.0)	5 (50.0)	17 (81.0)	7 (87.5)
Others	0	0	0	0	0
Unable to classify	0	0	0	0	0
Total	9 (100.0)	16 (100.0)	10 (100.0)	21 (100.0)	8 (100.0)

Read Japanese Kana aloud test	Case 1	Case 2	Case 3	Case 4	Case 5
Vowel errors	0	4 (17.4)	4 (40.0)	13 (26.0)	0
V+C errors	0	3 (13.0)	3 (30.0)	6 (12.0)	2 (16.7)
Consonant errors	3 (60.0)	16 (69.6)	3 (30.0)	31 (62.0)	10 (83.3)
Others	2 (40.0)	0	0	0	0
Unable to classify	0	0	0	0	0
Total	5 (100.0)	23 (100.0)	10 (100.0)	50 (100.0)	12 (100.0)

V+C errors, vowel and consonant errors

made a larger proportion of metathesis errors (>40%) than the two patients with Wernicke's aphasia (15-25%). The percentage of metathesis errors on the other tests, i.e., naming, read Japanese Kanji aloud and read Japanese Kana aloud tests, made by the patients with conduction aphasia and the patients with Wernicke's aphasia did not differ significantly. Metathesis errors were more frequently seen on the read Japanese Kana aloud test than on the read Japanese Kanji aloud test in four of the five patients.

5) Classification of substitution and metathesis errors

Table 2 summarizes the substitution and dislocation errors made by each patient. On the naming test taken by the two patients with conduction aphasia, vowel errors comprised 33% of the errors of Case 1 and 29% of the errors of Case 2; consonant errors comprised 48% of the errors of Case 1 and 53% of the errors of Case 2; and vowel and consonant errors comprised 15% of the errors of Case 1 and 14% of those of Case 2. On the other hand, in Cases 3 and 4 with Wernicke's aphasia, vowel errors comprised only approximately 10% of the total errors on the naming test.

In Case 3 who had mild Wernicke's aphasia, 43% of the errors on the naming test were vowel and consonant errors, while only 8% were vowel errors which is a much smaller percentage than that seen in the patients with conduction aphasia. On the naming test, consonant errors comprised 47% of the total errors of Case 3, who had the mild form of the disease, while consonant errors comprised 76% of the total errors of Case 4, who had moderate Wernicke's aphasia. Since Case 5 had a total of three substitution and metathesis errors on the naming test, this case was not included in the analysis.

On the repetition test, vowel errors were made more frequently by the patients with conduction aphasia than by those with Wernicke's aphasia, although the percentage of vowel errors made by Case 2 and Case 3 were similar. On the other hand, consonant errors were seen more frequently in the patients with Wernicke's aphasia than in the patients with conduction aphasia, with such errors accounting for 70-90% of the total errors in the Wernicke's aphasia patients. The percentage of consonant errors was particularly high in Case 4, who had the most severe impairment of auditory language

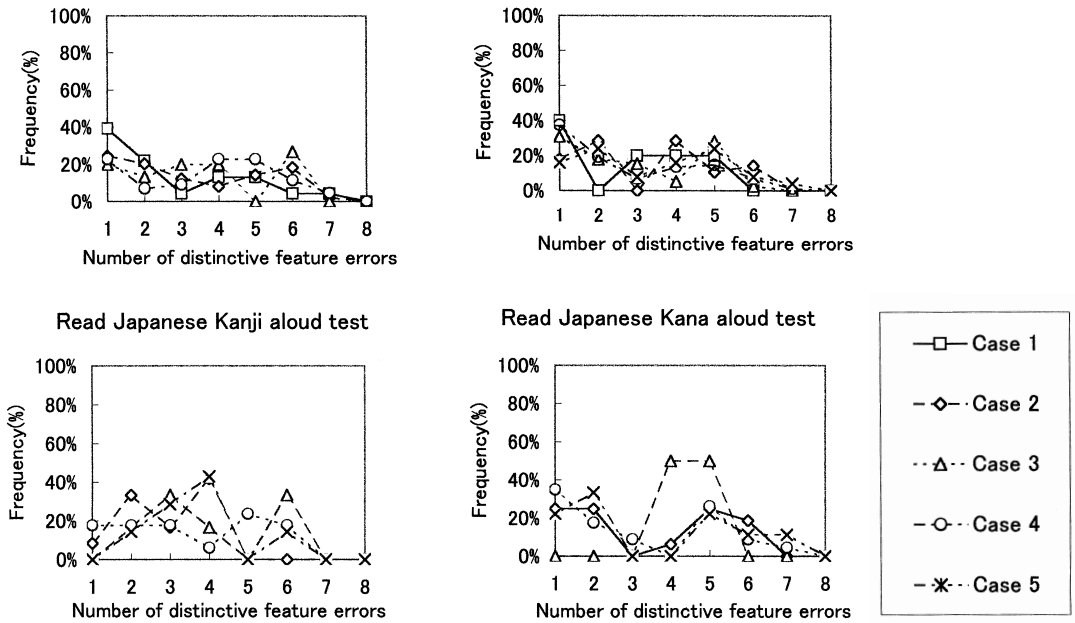

Fig. 10 Analysis of errors of the consonant in the substitution errors by distinctive feature framework -dislocation. The results of Case 5 on the naming test, and those of Case 1 on the read Japanese Kanji and Kana aloud tests, were omitted from the analysis, because the number of substitution errors was very small.

comprehension among the three patients with Wernicke's aphasia.

On the read Japanese Kanji aloud test, Case 1 made no consonant errors. The percentage of consonant errors made by Case 2 and Case 3 on this test was 50%, and among the patients with Wernicke's aphasia, there was a tendency for the frequency of consonant errors on the read Japanese Kanji aloud test to increase as the severity of the disease increased.

On the read Japanese Kana aloud test, approximately 60% of the errors made by the patients with conduction aphasia were consonant errors. Among the patients with Wernicke's aphasia, the frequency of vowel errors decreased as the severity of the disease increased, while the frequency of consonant errors increased.

6) Analysis of errors of the consonant in the substitution errors by distinctive feature framework

Since Case 1 had few substitution errors on the read Japanese Kanji aloud test and Case 5 had few substitution errors on the naming test, these cases were not included in the analysis of the respective test. As shown in fig. 10, the percentage of substitution errors made by the patient with conduction aphasia (Case 2) and that made by the patients with Wernicke's aphasia (Cases 3, 4) on each language modality test, did not differ significantly. The frequency of each specific number of distinctive feature errors among the substitution errors on each language modality test did not significantly differ among the 5 patients (fig. 10).

DISCUSSION

1) Diagnosis of conduction aphasia and Wernicke's aphasia

It has been believed that patients with conduction aphasia are capable of fluent and practical conversation and have no impairment of auditory language comprehension, but have phonological paraphasia in every language modality and impairment in repetition. As shown by the results of the SLTA profile and the Token Test, Cases 1 and 2 can comprehend language to the degree that they have no problems in routine conversation, although they were diagnosed as having conduction aphasia because they made errors that are characteristic of patients who have phonological paraphasia.

On the other hand, Wernicke's aphasia is characterized by the production of fluent but meaningless paraphasic words and by impairment of language comprehension. As shown by the results of the SLTA profile and the Token Test, Cases 4 and 5 could not comprehend verbal commands and had severe impairment of auditory language comprehension; therefore, these patients were considered to have Wernicke's aphasia. Diagnosis was difficult in Case 3. Although this patient had a rather good score on the Token Test and could exchange routine conversation fairly well, he had difficulty discriminating speech sounds and catching single sounds, and exhibited confusion indiscriminating words with different numbers of syllables. These results differed from those of Cases 1 and 2 with conduction aphasia. Goodglass *et al.* [6] reported that patients with conduction aphasia have good recognition of words containing various numbers of syllables. Although Cases 1 and 2 made naming and repetition errors on multi-syllabic words, they could catch single sounds and recognize words with varying numbers of syllables. Thus, Case 3 was diagnosed with Wernicke's aphasia even though he could comprehend the context of a sentence relatively well. In summary, patients with conduction aphasia and Wernicke's aphasia included in this study were differentiated based on language comprehension and speech sound recognition, not on utterance.

2) Utterance in patients with conduction aphasia

Although Warrington and Shallice [14] considered that conduction aphasia is characterized by impairment of repetition due to poor auditory verbal short-term memory, our two cases did not have significant problems with repetition. They had more problems with naming objects on cards, a finding in accordance with the results reported by Burns and Canter [3], Monoi *et al.* [10], and Otsuki *et al.* [11].

In our study, the two patients with conduction aphasia had better scores on the read Japanese Kanji and Kana aloud tests than on the repetition test. These results suggest that patients with conduction aphasia need some clues to find words, and those

visible clues are more effective than auditory clues. We also recognized that these two patients had phonological paraphasia and conduites d'approche errors of the target words on all four-language modality tests, as previously reported [15].

Yamadori [15] reported that patients with conduction aphasia have more difficulty in producing words with a greater number of syllables. Our results showed a similar tendency. In the two patients with conduction aphasia, the percentage of correct answers decreased dramatically when the number of syllables in the target word reached a specific number, and these patients were unable to produce words of more than five syllables. Since this tendency was seen not only on the repetition test but also on the naming test, the impairment cannot be due to simply a reduction in auditory verbal short-term memory. More accurately, the impairment may be due to a reduction in the capacity of the auditory image, as pointed out by Yamadori [15].

More detailed analyses of the phonological paraphasia in the two patients with conduction aphasia showed that they had many metathesis errors on the repetition test. Since the questions on the repetition test are given verbally and suggest the target word, it is assumed that the examinees had better clues to the correct verbal answers than on the naming tests. On the repetition test, the two patients with conduction aphasia had many metathesis errors, and this suggests that even though they could approach the target word through the use of sound clues, they could not repeat the target word due to a reduction in the capacity of holding the auditory image. As a result, they seemed to change the target word to a word with more simple sounds and composed of repetitive sounds.

Before this study was conducted, we speculated that the patients with conduction aphasia would do better on the read Japanese Kana aloud test than on the other language modality tests that require the formation of an auditory image before giving the answer. In the Kana test, the patient simply reads each letter one by one. In the Kanji test, the patient needs to form an auditory image through the visual image of the word, not individual letters. In contrast to our speculation, Case 2 performed better on the read Japanese Kanji aloud test than on the Kana test, in which the 80 target words in the read Japanese Kanji aloud test were among the 110 words in the read Japanese Kana aloud test. Case 2 seemed to form an auditory image of the word and not an auditory image of each letter in the word. Because it is more difficult to understand the meaning of words composed of Kana letters than the meaning of words composed of Kanji letters, the auditory image of Kana-letter-words might have been more fragile than the auditory image of Kanji-letter-words in Case 2.

Regarding phonological paraphasia, the two patients with conduction aphasia made errors in both vowels and consonants. However, on the naming and repetition tests, both patients made more vowel errors than consonant errors. Ueda and Watamori (1985) reported that patients with conduction aphasia use various strategies to collect a word. In these tests, the strategy that our two patients with conduction aphasia used for choosing a letter seemed to involve picking a sound from the same column (the correct consonant phoneme and the incorrect vocalic phoneme) in the Japanese alphabettable (see footnote 5) as that of the corresponding letter in the target word, and notpicking a sound from the same row (incorrect consonant phoneme and correct vocalic phoneme).

The performance of the two patients with conduction aphasia on the read Japanese Kanji aloud test, differed significantly. Also, in these two patients approximately 60% of the speech sound errors on the read Japanese Kana aloud test were consonant errors. These results suggest that there is a mechanism by which the visual input affects the auditory image. Further studies are needed to clarify the instability of the auditory image in patients with conduction aphasia.

3) Utterance in patients with Wernicke's aphasia

The three patients with Wernicke's aphasia showed various types of speech sound errors. Particularly on the naming test, they

Footnote 5 In the table of the Japanese alphabet, letters are written in 10 columns (starting with the letters A, KA, SA, TA, NA, HA, MA, YA, RA, WA) and five rows (a, i, u, e, o). The total number of letters in the alphabet is 50 + 1 (N).

demonstrated verbal paraphasia with semantic substitution, and the percentage of such errors decreased as the severity of the disease increased. This result suggests that milder cases of Wernicke's aphasia have a milder degree of impairment in their phonological and semantic lexicons.

We found that in the phonological paraphasia of Wernicke's aphasia, patients made consonant errors more often than vowel errors. As the severity of the disease increased, the number of errors in sound units comprised of an incorrect consonant phoneme and a correct vocalic phoneme, increased. Luria [9] reported that patients with acoustico-gnostic aphasia have impairment in discriminating opposite phonemes such as p-b, t-d, and s-z, as well as related phonemes such as m-n, and that this is a unique characteristic of acoustico-gnostic aphasia because of local lesions in Wernicke's area in man. The three patients with Wernicke's aphasia in this study had problems in the speech-sound discrimination test. Even Case 3, in whom comprehension of the meaning of a sentence was rather well maintained, had this difficulty. Although it is considered that there exist differences among languages due to differences in phonemic elements, Japanese patients with Wernicke's aphasia seem to have problems in collecting the target word due to impairment in discriminating consonants in the same vocalic phoneme. This seems to be characteristic of patients with Wernicke's aphasia.

4) Similarities and differences of utterance between conduction aphasia and Wernicke's aphasia

The percentage of correct answers on words with different numbers of syllables, types of errors, and the ratio of errors in vowels and consonants, differed significantly between the two patients with conduction aphasia and the three patients with Wernicke's aphasia. The speech sound errors made by the two patients with conduction aphasia were mainly phonological paraphasia and conduites d'approche errors to the target word, while the speech sound errors made by the three patients with Wernicke's aphasia varied. On the naming test, the percentage of errors of verbal paraphasia with semantic substitution was inversely related to the severity of Wernicke's aphasia.

Although Case 1 (conduction aphasia) and Case 3 (Wernicke's aphasia) had a similar degree of auditory comprehension and both had a score of 75% on the Token Test, the types of errors made by Case 1 and Case 3 were quite different on each language modality test. In the substitution and metathesis errors on the naming and repetition tests, the two patients with conduction aphasia made more errors in vowels, while the three patients with Wernicke's aphasia made more errors in consonants. In the two patients with conduction aphasia, the percentage of correct answers generally decreased as the number of syllables in a target word increased, while in the patients with Wernicke's aphasia a linear relationship between the percentage of correct answers and the number of syllables in a target word, did not exist. It is assumed that the patients with Wernicke's aphasia could answer correctly regardless of the number of syllables if the target word was a word that was frequently used by the examinee. These results indicate that the speech sound errors seen in patients with Wernicke's aphasia cannot be due to a reduction in the capacity of holding an auditory image. Thus, we conclude that utterance of conduction aphasia is qualitatively distinct from that of Wernicke's aphasia remaining at least one year after onset. Although the two types of aphasia differ, the difference between the two types of aphasia does not seem to affect the programming of speech articulation because there were no differences in the number of distinctive feature errors between patients with conduction aphasia and those with Wernicke's aphasia.

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