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CONSTRUCTION OF A SHORT TEST OF APHASIA ON THE BASIS OF FACTOR ANALYSIS

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Construction of a Short Test of Aphasia on the Basis of Factor Analysis

One of the basic requirements for a reliable test of aphasia is that the test provides a balanced set of tasks over a wide range of linguistic abilities. In order to satisfy this requirement, the conventional test of aphasia usually comprises a large number of subtests, with the result that a considerable period of time is necessary to administer the entire test to the patients (usually two to three hours). From the standpoint of clinical efficiency, however, a shorter test should also have its place, provided that its limitations as compared to longer tests are clearly specified.

In a previous study by one of the authors (Y. F.), a method of reducing the size of a test battery without transforming the factor structure of that battery was investigated, on the assumption that if the basic components of the factor structure obtained from one test are identical to those obtained from another test, then the two tests can be considered to be measuring the same sets of attributes represented by these components or factors. The number of subtests of the Schuell-Sasanuma Examination of Aphasia was reduced from the original 23 to 17 and then to 13 according to certain criteria, or what may be called "rules of reduction", and the test scores of 205 aphasic patients on each of these three sized batteries were subjected to a series of factor analyses. The results obtained indicated that the number of subtests can be reduced considerably without changing the original factor structure, provided that the reduction is carried out on the basis of the following rules:

1. Of the factors identified in the original long test, select those which are considered to be essential components of the factor structure representing aphasic symptomatology.
2. For each of these factors select at least two subtests in the battery with high loadings on that factor.
3. If there are more than two subtests with high loadings on a given factor, several more subtests can be added to increase the diagnostic power of the short battery.

The purpose of the present investigation, then, was to construct a short test of aphasia on the basis of these three rules and to examine its clinical usefulness. The two conditions that had to be met by the shortened version of the test were (1) that the factor structure obtained from the shortened version be similar to that obtained from the original long battery, and (2) that the shortened version thus developed be sensitive enough to reliably screen the aphasics from the nonaphasics as well as classify the aphasics into major clinical types.

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Procedure

The study consisted of the following three stages:

Stage 1: Obtaining the factor structure of aphasic impairment. In order to obtain a reliable factor structure for aphasic impairment, the 56-subtest Comprehensive Examination of Aphasia (CEA, which is the latest revised version of the Schuell-Sasanuma Diagnostic Test of Aphasia) was administered to 180 consecutive cases of adult aphasia, and the obtained test scores were put into a factor analysis (FA 1).

Stage 2: Constructing a short test of aphasia. According to the three rules for reducing test size, 16 of the 56 subtests in the CEA were selected to construct a short version. This version was administered to the same group of 180 aphasic patients and the test scores thus obtained were put into the second factor analysis (FA 2), in order to ascertain that the factor structure found in the original battery is also found in the shortened version.

Stage 3: Testing the clinical usefulness of the short test of aphasia. The shortened version of 16 subtests was examined in terms of its clinical usefulness for evaluating clinical types and severity of aphasic impairment in the 180 patients.

In each of the factor analyses above an intercorrelation matrix calculated from the scores of the test items was subjected to principal axis analysis and subsequently to orthogonal rotation.

Results and Remarks

Stage 1. The factor structure of aphasic symptomatology.

The factor analysis of the test scores obtained from the administration of the long test to 180 patients (FA 1) resulted in the identification of 9 factors as shown in Table 1. The nature of each of these factors must be inferred from the pattern of distribution of subtests with high factor loadings on that factor. Thus, Factor 1 was interpreted as an Integrating Factor of Language Behavior on the basis of the following observations: that (1) the subtests with high loadings on Factor 1 were distributed across all modalities of language (i.e., oral expression, auditory comprehension, writing, reading, and calculation) and also represented a wide range of linguistic abilities; and that (2) these were so-called "difficult" tasks for the majority of the patients. By means of similar procedures, the remainder of the factors were identified as follows: F2: Word Comprehension, F3: Phonological Processing, F4: Motor Functions of Speech Organs, F5: Visuomotor Ability, F6: Numerical Concept, F7: Calculation, and F8: Fluency. No adequate interpretation was possible for the last factor(F9).

The factor structure thus obtained is essentially similar to those obtained in previous studies, [2-4] indicating that it is a fairly reliable factor structure for aphasic impairment available at this time.

Stage 2. Construction of a short test.

In accordance with the three rules of reduction, 56 subtests in the original version were reduced to 16. That is to say, on the basis of Rule 1, 6 of the 8 factors were selected. The other two factors, i.e., factors of

numerical concept and of calculation, were discarded because these were considered to be less crucial for the diagnosis and classification of aphasia. According to Rule 2, 12 subtests with high loadings on any one of the 6 factors were selected from the 56 subtests in the long battery. Four additional subtests were then included according to Rule 3.

The test scores of the 180 patients on these 16 subtests, then, were put into Factor Analysis 2, which resulted in the identification of 5 factors, as shown in Table 2. As is clear from the table, the 5 factors derived from the shortened tests are identical with the first 5 factors having the highest common factor variance of the original long battery. The loss of the sixth factor, i.e., the factor of fluency, was considered to be due to the fact that the common factor variance on this factor was lowest. These results thus indicate that the factor structure obtained with the shortened test is highly similar to that obtained with the original, longer battery.

Stage 3: Clinical usefulness of the short test.

Two approaches were taken for evaluating the clinical usefulness of the shortened test. In the first approach, the 180 patients were classified into Schuell's 7 clinical types of aphasia on the basis of two sets of data: the test score patterns derived from the shortened test, and those derived from the original long test. One of the authors (Y. F.) did the classification task on the basis of the former data and the other author (S. S.) the latter, independently. Table 4 shows the results of these classifying tasks. It is clear from the table that the agreement between the two independent sets of judgments based on the long and the short tests is quite high (a complete agreement was obtained on the classification of 96% of the subjects), indicating that the two tests are similar in terms of their power to classify the patients into major clinical types.

In the second approach, the relationship between the performance level on the short test and that on the long test for each individual was investigated. The results are summarized in Figure 1, where the ordinate represents the total scores on the short tests and the abscissa those on the long test, with each circle representing a patient. As is clear from the figure, a linear interrelationship was obtained ($r = 0.98$), indicating that the short test is quite similar to the long test in terms of its power to evaluate the severity level (reflected in the total score) of individual patients.

On the basis of these findings, it can be tentatively concluded that the new short test of aphasia comprised of 16 subtests is indeed a useful test for screening aphasic patients in a relatively short period of time (approx. 30 min.) as well as for making a rough estimation on the major clinical types and severity of aphasic impairments. Needless to say, however, the short test cannot altogether replace the long comprehensive test due to its inherent limited capacity to extract other kinds of information, i.e., such as that which is necessary for framing therapy plans and following recovery processes for individual patients.

TABLE 1.

Varimax matrix showing principal axes factor loadings* above |0.30| of the 56 subtests. The eight factors are as follows: Factor 1, integrating factor of language behavior; Factor 2, word comprehension; Factor 3, phonological processing; Factor 4, motor functions of speech organs; Factor 5, visuomotor ability; Factor 6, numerical concept; Factor 7, calculation; Factor 8, fluency.

Test Number	Task	Factor 1	2	3	4	5	6	7	8	9
1.	point to pictures of objects named (high frequency word)		65	-38		-31				
2.	point to pictures of objects named (low frequency word)		64	-31						
3.	point to items named serially	56	44	-44						
4.	point to numbers named serially (forward)	61	33	-45						
5.	point to numbers named serially (backward)	69		-34						
6.	listen to short sentences, match pictured action									
7.	follow spoken directions	55	43	-52						
8.	listen to paragraph, answer questions yes or no		51	-46						
9.	count aloud 1 to 10			-63						
10.	repeat sentences	44		-74						
11.	name pictures of objects (high frequency word)	35	30	-75						
12.	name pictures of objects (low frequency word)	51		-67						
13.	enumerate words that start with a given sound	68		-45						
14.	enumerate words that belong to a given semantic category	66		-50						
15.	describe pictured action	44		-73						
16.	describe pictured situation	48	32	-68						
17.	point to letters (kana) named	32	51	-57						
18.	match printed words with pictures (kanji)		79	-35						
19.	match printed words with pictures (kana)	42	66	-45						
20.	match spoken, printed words (kanji)		77	-36						
21.	match spoken, printed words (kana)		70	-50						
22.	read short sentences, match pictured action		78							

* Decimal points are omitted for all entries on the body of the table. These factors account for 95% of the estimated common factor variance.

Number	Task	1	2	3	4	5	6	7	8	9
23.	follow printed directions	70	32	-44						
24.	read paragraph, check questions yes or no		64	-31						
25.	read letters (kana) aloud		31	-80						
26.	read words (kanji) aloud		38	-82						
27.	read words (kana) aloud		45	-78						
28.	read short sentences aloud		31	-79						
29.	write numbers 1 to 10		47	-36		-46				
30.	write dictated letters (kana)	34	47	-61						
31.	write names of pictured objects (kanji)	38	47							52
32.	write names of pictured objects (kana)	45		-32						77
33.	write dictated words (kanji)	47	56	-38						
34.	write dictated words (kana)	36								82
35.	write short sentences about pictured action	85								
36.	write dictated short sentences	83								
37.	write paragraph about pictured situation	80								
38.	match tokens with numbers named		49	-31			-60			
39.	match tokens with printed numbers		40				-51			
40.	point to numbers named		54	-41		-30	-44			
41.	solve simple problem in addition		45					45		
42.	solve simple problem in subtraction	37	48					46		
43.	solve simple problem in multiplication	39	36	-44				41		
44.	solve simple problem in division	53						45		
45.	solve problem in addition	52	31					38		
46.	solve problem in subtraction	51						47		
47.	solve problem in multiplication	61								
48.	solve problem in division	55						30		
49.	phonemic paraphasia			-70					-39	
50.	fluency			-54					-53	
51.	imitate examiner: palatal movements				-83					
52.	difficulty in swallowing				-83					
53.	repeat monosyllables rapidly			-51					-49.	
54.	repeat three-syllables (pa-ta-ka) rapidly			-57					-41	
55.	copy letters (kanji)					-85				
56.	copy letters (kana)					-86				

Table 2. Varimax matrix showing principal axes factor loadings* above |0.30| of the 16 subtests. The five factors are as follows: Factor 1, integrating factor of language behavior; Factor 2, word comprehension; Factor 3, phonological processing, Factor 4, motor functions of speech organs; Factor 5, visuomotor ability.

Test Number	Task	Factor 1	2	3	4	5
1.	point to pictures of objects named (high frequency word)		70			
2.	repeat sentences	-54	43	-49		
3.	name pictures of objects (high frequency word)	-53	48	-52		
4.	describe pictured situation	-56	50	-49		
5.	match printed words with pictures (kana)	-37	73			
6.	match spoken, printed words (kanji)		79	-30		
7.	write names of pictured objects (kana)	-66				
8.	write dictated short sentences	-69				
9.	phonemic paraphasia			-76		
10.	fluency			-74		
11.	imitate examiner: palatal movements				-84	
12.	difficulty in swallowing				-83	
13.	repeat monosyllables rapidly			-75		
14.	repeat three-syllables (pa-ta-ka) rapidly			-73		
15.	copy letters (kanji)					-90
16.	copy letters (kana)					-90

* Decimal points are omitted for all entries in the body of the table.
These factors account for 97% of the estimated common factor variance.

Table 3. Classification of 180 aphasic subjects into clinical types on the basis of the short and long test performances.

		Long Test								
		I	I+Dys.	III	IV	V	MA	Others	Unclassifiable	
Short Test	I	83								
	I + Dys.		16							
	III			31					1	
	IV				4					
	V			1		26	2			
	MA						4			
	Others							1		
	Unclassifiable	2			1				8	
		85	16	32	5	26	6	1	9	180

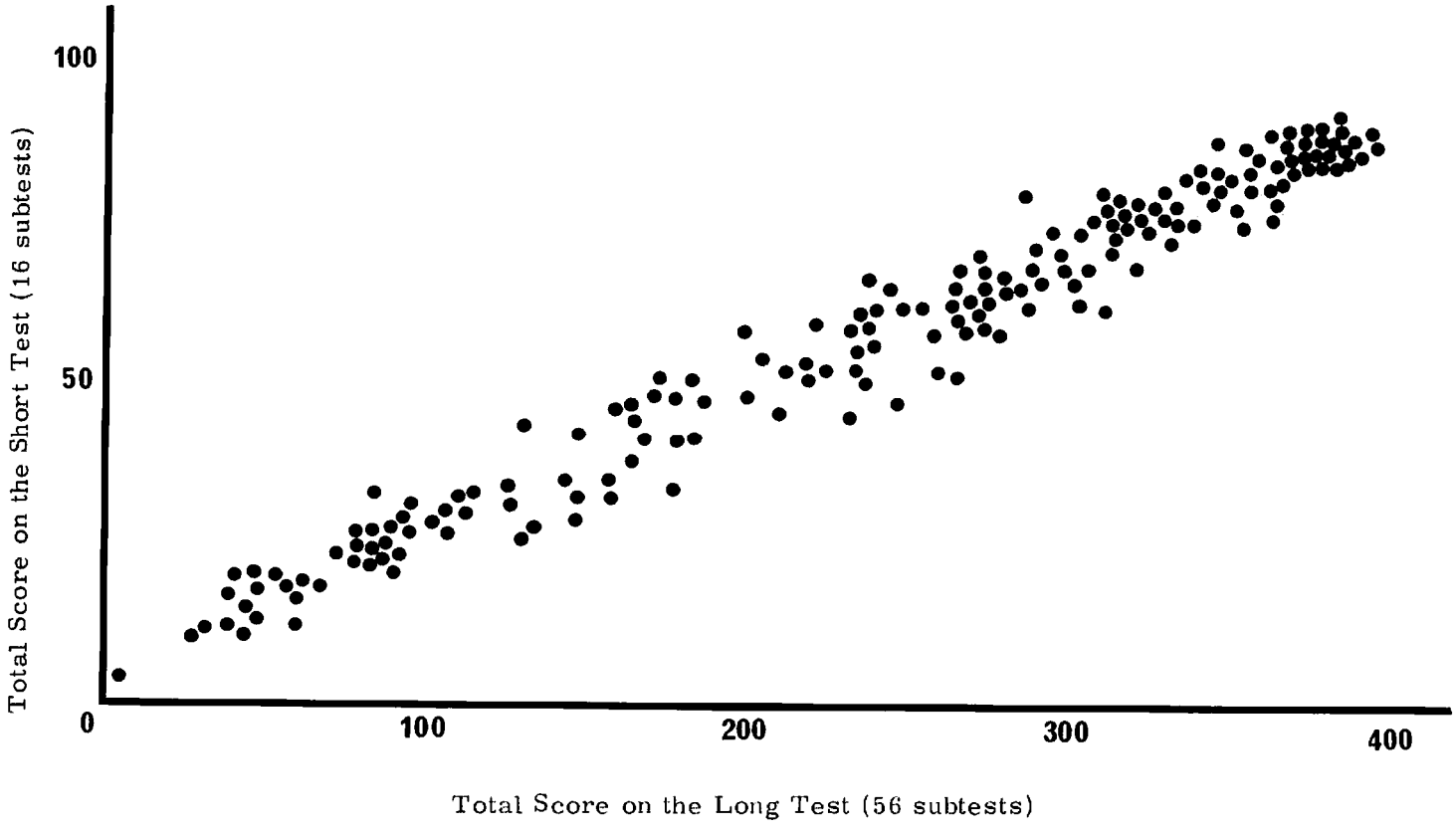

Fig. 1. Distribution of 180 aphasic subjects in terms of the total score on the short test against the total score on the long test.

References

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* Japanese Text.