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# The effects of speech therapy for aphasic patients in Japan on linguistic function, functional communication ability in daily life, and non-linguistic intelligence

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**Objective:** We analyzed retrospective data from aphasic patients regarding linguistic function, practical communication function in daily life, and non-linguistic intelligence and determined the degree of these improvements using multivariate analysis.
**Methods:** The subjects were 88 patients who received intensive speech therapy provided by a language-speech-hearing therapist during the recovery period of aphasia. We collected data from the Standard Language Test of Aphasia, Test of Communicative Ability of Daily Living short form, and Raven's Coloured Progressive Matrices Test at the beginning and at the end of speech therapy. The improvement scores were defined as the difference of scores obtained at the first and the final evaluation. We applied factor analysis to the improvement scores.
**Results:** Our factor analysis with and without factor rotation did not extract a general factor, but did extract 6 improvement factors for which their eigenvalues were 1.0 or larger, which accounted for 66.1% of the sum of the variance. The structure of improvement in aphasic patients was not uniform. There was a close, significant relationship between the essential improvement of language function and the improvement of functional communication ability. Conversely, the improvement of non-linguistic intelligence was independent of these changes.
**Conclusions:** The essential improvement of language function is directly linked to the improvement of functional communication ability in daily life. And the structure for improving non-linguistic intelligence is different from that for improving linguistic function and communication ability in daily life.

**Key words:** aphasia, speech therapy, factor analysis

**Abbreviations:** SLTA, Standard Language Test of Aphasia; CADL, Test of Communicative Ability of Daily Living: RCPM, Raven's Coloured Progressive Matrices Test

## Introduction

In speech therapy for aphasia, several tests are typically performed at the beginning of treatment to determine the appearance of various symptoms presented by the patient and then re-evaluated after a certain period of treatment to determine their improvement. Several important tests are performed, and there is a differential diagnostic test for evaluating the overall language function of aphasia described according to the language modality. The Standard Language Test of Aphasia (SLTA)[1] is used most frequently and is widely recognized as a reliable assessment in Japan. This test consists of 26 subtests addressing four modalities (speaking, listening, writing, and reading), three component levels (phoneme, word, and sentence), and two distinct character types of Japanese language ("*kanji*" and "*kana*").

In addition to the evaluation of language functions measured by the SLTA, the evaluation of functional communication ability, such as answering yes/no,

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answering questions that were not heard, or understanding TV programs is important in considering the quality of life of aphasic patients. Furthermore, as aphasia is a disorder that impairs language function, which is an important cognitive function, it is common to evaluate changes in the level of intelligence as well.

In the present study, we analyzed data retrospectively and performed multivariate analyses to comprehensively understand the improvement in aphasic patients as revealed in test scores obtained following their speech therapy. The targets of the analysis were: the improvement of language function, functional communication ability, and non-linguistic intelligence that can be measured using the SLTA, the Test of Communicative Ability of Daily Living (CADL) short form,[2] and Raven's Coloured Progressive Matrices Test (RCPM), respectively.

## Materials and Methods

*Subjects*

The subjects in this study included 88 aphasic patients who met the following criteria: 1. were treated sometime between 2014 through 2018, 2. in Koshu Rehabilitation Hospital, 3. received intensive speech therapy during the recovery period by a language-speech hearing therapist (ST), and 4. their language disturbance was evaluated using the SLTA, the CADL short form, and the RCPM at the beginning and at the end of their speech therapy during their hospital stay. Table 1 summarizes the subjects' characteristics.

*Procedure*

1. Factor analysis of improvement scores from the SLTA 26 subtests, the CADL short form, and the RCPM

The improvement scores were defined as the difference in the scores obtained at the first and at the final evaluations during the hospital stay. We used principal component analysis on the improvement scores. The variables included 28 improvement scores: 26 SLTA subtests, the CADL short form, and the RCPM. We examined whether a general factor was able to be extracted. When several factors were extracted without extracting a single general factor, we identified them respectively. SPSS (Version 25) statistics software was used for all the analyses.

2. Correlation analyses among the improvement factors and the subjects' characteristics

When several factors were extracted following the factor analyses, we conducted correlation analyses among the improvement factors and the subjects' characteristics. The subjects' characteristics included: age, education level, disease duration (in days), speech therapy duration (i.e., interval between evaluations, in days); at the beginning of speech therapy, the total SLTA subtest scores, the CADL short form score, and the RCPM score; the general improvement score of the SLTA (the total of all 26 improvement scores), and the years of experience of the ST performing the therapy. Among these, education level was evaluated on a five-point scale: compulsory education graduate, high school graduate, vocational school or junior college graduate, university graduate, and postgraduate education. Regarding age, in addition

**Table 1.** Subjects' characteristics (N = 88*)

| | |
|---|---|
| Age (years) | |
| Mean ± SD (range) | 66.2 ± 15.2 (24−88) |
| Sex | |
| Male | 46 |
| Female | 42 |
| Dominant hand | |
| Right | 84 |
| Left | 2 |
| Unknown | 2 |
| Diagnosis | |
| Cerebral infarction | 41 |
| Intracerebral hemorrhage | 27 |
| Subarachnoid hemorrhage | 6 |
| Trauma | 4 |
| Other | 10 |
| Education level (years) | |
| 9 | 11 |
| 12 | 30 |
| 15 | 11 |
| ≥16 | 9 |
| Unknown | 27 |
| Paralysis | |
| Right paralysis | 61 |
| Left paralysis | 5 |
| Paraplegia | 5 |
| No paralysis | 17 |
| Disease duration (days) | |
| Mean ± SD (range) | 44.4 ± 24.2 (8−137) |
| Speech therapy duration (days) | |
| Mean ± SD (range) | 99.5 ± 41.7 (22−171) |
| ST's experience (years) | |
| Mean ± SD (range) | 5.4 ± 4.0 (1−15) |
| Initial SLTA score | |
| Mean ± SD (range) | 122.6 ± 61.9 (0−233) |
| Initial CADL score | |
| Mean ± SD (range) | 71.2 ± 36.6 (0−126) |
| Initial RCPM score | |
| Mean ± SD (range) | 18.8 ± 10.8 (0−36) |

*Aphasic patients

**Table 2.** Matrix of improvement factors for comunnication and intelligence in aphasia

| SLTA subtests/CADL/RCPM | Improvement factors | | | | | |
|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | F5 | F6 |
| Writing from dictation: "*kana*" words | 0.826* | -0.004 | 0.091 | -0.110 | -0.018 | 0.061 |
| Writing from dictation: "*kanji*" words | 0.793* | 0.019 | -0.057 | -0.176 | -0.107 | -0.136 |
| Understanding written commands | 0.784* | -0.132 | -0.072 | 0.223 | -0.102 | 0.000 |
| Writing confrontation naming: "*kanji*" words | 0.783* | -0.183 | -0.067 | -0.193 | 0.053 | -0.096 |
| Writing confrontation naming: "*kana*" words | 0.782* | -0.081 | -0.042 | 0.053 | -0.023 | 0.094 |
| Writing from dictation: "*kana*" letters | 0.764* | 0.160 | 0.008 | -0.199 | 0.207 | -0.201 |
| Visual confrontation naming | 0.747* | 0.143 | 0.370 | 0.037 | 0.013 | -0.049 |
| Story writing | 0.668* | -0.115 | -0.124 | 0.439 | -0.091 | 0.099 |
| Calculation | 0.664* | -0.011 | 0.142 | 0.216 | 0.131 | 0.132 |
| Visual confrontation action naming | 0.625* | 0.225 | 0.205 | -0.002 | 0.006 | -0.002 |
| CADL | 0.587* | 0.345 | 0.040 | -0.025 | 0.172 | 0.419 |
| Understanding oral commands | 0.550* | -0.069 | -0.016 | 0.482 | -0.095 | 0.047 |
| Understanding written commands | 0.549* | 0.017 | -0.127 | 0.471 | 0.065 | 0.322 |
| Narration | 0.542* | 0.120 | -0.084 | 0.447 | 0.049 | 0.046 |
| Oral reading: text | 0.513* | 0.146 | 0.422 | -0.148 | 0.306 | 0.071 |
| Reading comprehension: text | 0.457* | 0.400 | 0.030 | -0.146 | 0.228 | 0.298 |
| Reading comprehension: "*kana*" words | -0.048 | 0.868* | 0.250 | 0.037 | 0.009 | -0.019 |
| Reading comprehension: "*kanji*" words | -0.006 | 0.852* | 0.301 | 0.042 | 0.027 | -0.058 |
| Auditory comprehension: words | 0.123 | 0.747* | 0.080 | -0.285 | 0.083 | 0.114 |
| Auditory comprehension: text | 0.509 | 0.645* | -0.171 | 0.032 | 0.055 | -0.014 |
| Oral reading: "*kana*" letters | 0.319 | 0.272 | 0.683* | -0.132 | 0.038 | 0.180 |
| Oral reading: "*kana*" words | 0.043 | 0.305 | 0.671* | 0.058 | 0.281 | 0.065 |
| Oral reading: "*kanji*" words | 0.277 | 0.403 | 0.646* | -0.057 | -0.303 | -0.230 |
| Word enumeration | 0.328 | -0.268 | 0.017 | 0.560* | 0.089 | -0.089 |
| Auditory comprehension: "*kana*" letters | 0.314 | 0.395 | 0.070 | -0.446* | 0.056 | 0.349 |
| Word repetition | 0.159 | 0.308 | 0.057 | -0.201 | 0.718* | 0.103 |
| Sentence repetition | 0.251 | -0.038 | 0.127 | 0.288 | 0.711* | -0.175 |
| RPCM | 0.300 | 0.057 | 0.084 | 0.005 | -0.082 | 0.809* |

Extraction method: principal component analysis; rotation method: quartimax with Kaiser normalization
*Factor loadings >0.45

**Table 3.** Correlation between improvement factors and subjects' characteristics

| Factors | Characteristics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age | Older age judgement ≥65 yo | Older age judgement ≥75 yo | Education level | Disease duration | Speech therapy duration | Initial SLTA score | Initial CADL sore | Initial RCPM sore | SLTA general improvement score | ST's experience |
| F1 | -0.113 | -0.111 | -0.280** | -0.096 | -0.219* | 0.304** | -0.029 | 0.038 | 0.078 | 0.873** | 0.009 |
| F2 | 0.267* | 0.253* | 0.294** | 0.113 | -0.076 | 0.279** | -0.606** | -0.522** | -0.371** | 0.344** | 0.128 |
| F3 | -0.056 | -0.129 | -0.062 | 0.187 | -0.003 | 0.026 | -0.213* | -0.084 | -0.024 | 0.247* | 0.084 |
| F4 | -0.127 | -0.208 | -0.046 | -0.146 | -0.055 | 0.010 | 0.295** | 0.353** | 0.192 | 0.117 | 0.003 |
| F5 | 0.109 | 0.061 | 0.106 | -0.011 | -0.095 | 0.087 | 0.029 | 0.073 | 0.057 | 0.150 | 0.054 |
| F6 | 0.155 | 0.145 | -0.044 | 0.258* | 0.090 | 0.098 | -0.138 | -0.284** | -0.428** | 0.078 | 0.142 |

* $P < 0.05$, ** $P < 0.01$

to the actual age, a separate two-level evaluation was provided to compare elderly and young people, whereby 65 years old and older (older age judgment ≥65 yo) and 75 years old and older (older age judgment ≥75 yo) were used.

We also analyzed the correlations among the subjects' characteristics. Spearman's rho was used in the stage evaluation, and Pearson's correlation coefficient was used for all other correlations.

## Results

*Factor analysis of the improvement scores from the SLTA 26 subtests, the CADL short form, and the RCPM*

Our factor analysis with and without factor rotation did not extract a single general factor. However, 6 factors were extracted for which their eigenvalues were 1.0 or larger by rotating the quartimax method with Kaiser normalization. The 6 extracted factors accounted for 66.1% of the sum of the variance. The factor loadings obtained from each test are shown in Table 2.

*Correlation analyses among improvement factors and the subjects' characteristics*

Table 3 shows the correlations among the 6 improvement factors obtained from the factor analyses and the subjects' characteristics. The correlations between the subjects' characteristics are shown in Table 4.

## Discussion

*Factor analysis of improvement scores from the SLTA 26 subtests, the CADL short form, and the RCPM*

A single general factor was not extracted from the factor analyses, suggesting that the recovery of language function, functional communication ability, and non-linguistic intelligence was not uniform. We defined the extracted factors as, "Improvement factors for communication and intelligence in aphasia." We identified Factors 1－6 as: 1. Comprehensive improvement factor of language function and communication, 2. Comprehension improvement factor, 3. Oral reading improvement factor, 4. Word enumeration improvement factor, 5. Repetition improvement factor, and 6. Intelligence improvement factor.

In general, Factor 1 represents the overall ability of the principal component analysis. Summarizing the test items that make up Factor 1, for the SLTA subtest items, letter and word-level tasks (visual confrontation naming, visual confrontation action naming, writing confrontation naming: "*kanji*" words and "*kana*" words, writing from dictation: "*kana*" letters, "*kana*" words, and "*kanji*" words), complex information processing above the sentence level tasks (understanding oral commands, understanding written commands, story narration, story writing, reading comprehension: texts, oral reading: texts, and writing from dictation: sentences), and calculations were included. The improvement scores from the CADL short form were also added.

In our previous studies[3,4] we performed factor analyses

**Table 4.** Correlations among subjects' characteristics

| Characteristics | Characteristics | | | | |
|---|---|---|---|---|---|
| | Older age judgement ≥65 yo | Older age judgement ≥75 yo | Education level | Disease duration | Speech therapy duration |
| Age | 0.843** | 0.705** | 0.126 | -0.195 | 0.017 |
| Older age judgement ≥65 yo | 1.000 | 0.571** | -0.057 | -0.072 | 0.019 |
| Older age judgement ≥75 yo | | 1.000 | 0.003 | 0.007 | 0.027 |
| Education level | | 1.000 | 0.087 | 0.077 | -0.315 |
| Disease duration | | | 1.000 | -0.015 | -0.073 |
| Speech therapy duration | | | | | 1.000 |
| Initial SLTA score | | | | | |
| Initial CADL sore | | | | | |
| Initial RCPM sore | | | | | |
| SLTA general improvement score | | | | | |
| ST's experience (years) | | | | | |

* P < 0.05, ** P < 0.01

of the improvement scores for only the 26 SLTA subtests to ascertain the primary improvement mechanism in speech therapy. In those studies, the factor analyses derived 6 improvement factors, none of which were considered as corresponding to a single general factor. Factor 1 was determined to represent, "non-converting language production and complex language information processing." As Factor 1 appeared to embody the entirety of human language function and to manage symbols creatively and independently, we categorized this factor as, "The core factor of improvement in recovery from aphasia" and stressed its importance in speech therapy. The SLTA subtest items included in Factor 1 extracted in this analysis, generally constitute, "The core factor of improvement in recovery from aphasia" in our previous studies.

A correlation between improved SLTA and CADL short form scores has previously been established.[5,6] The results of the present study suggest that the patients' improvement as revealed by higher scores on the CADL short form, i.e., the improvement of functional communication abilities, have a very close relationship to the improvement indicated by, "The core factor of improvement in recovery from aphasia" among the language functions measured using the SLTA. Therefore, we identified Factor 1 as, "The comprehensive improvement factor of language function and communication."

While Factor 1 represented the overall ability of language function and communication, Factors 2－5 represented improvements associated with a particular language function, namely, comprehension, oral reading, word enumeration, and repetition. It was suggested that each of these functions had an independent improvement structure.

Finally, Factor 6, "The intelligence improvement factor," measured by the RCPM, was independent. The results of the present study suggested that the improvement of non-linguistic intelligence had an independent structure different from the improvement of various language symptoms, especially "The comprehensive improvement of language function and communication." Conventionally, it has been suggested that non-linguistic intelligence may decline with aphasia.[7,8] While this may seem contradictory, we were able to make one important consideration from this, that the structure of recovery from impairment might be different from the that of the impairment itself.

*Correlation analyses among improvement factors and the subjects' characteristics*

From the results of the correlation analyses, we concluded thusly regarding the following 6 Factors.

Factor 1: "The comprehensive improvement factor of language function and communication" was a factor that led to improvements by starting speech therapy early and continuing for a long term. It was shown that Factor 1 is an important factor that contributes mostly to the general improvement score on the SLTA. This improvement did not correlate with the difficulty of the SLTA, the CADL short form, or the RCPM scores at the beginning of speech therapy, and it showed a negative

| Initial SLTA score | Initial CADL sore | Initial RCPM sore | SLTA general improvement score | ST's experience (years) |
|---|---|---|---|---|
| -0.407 | -0.373 | -0.600** | -0.018 | 0.199 |
| -0.358 | -0.349 | -0.622** | -0.010 | 0.201 |
| -0.378 | -0.344 | -0.433** | -0.055 | 0.243* |
| -0.341 | -0.141 | 0.032 | -0.063 | |
| -0.115 | -0.070 | -0.217* | 0.096 | |
| -0.244 | -0.226 | -0.121 | -0.383** | -0.043 |
| 1.000 | 0.887** | 0.539** | -0.253* | -0.184 |
| | 1.000 | 0.614** | -0.113 | -0.214* |
| | | 1.000 | -0.053 | -0.141 |
| | | | 1.000 | 0.076 |
| | | | | 1.000 |

correlation in patients 75 years of age or older, suggesting that the improvement in this factor is inferior for elderly people 75 or older.

Factor 2: "The comprehension improvement factor" contrasted to Factor 1. This factor led to improvements following long-term speech therapy, which contributed to overall improvement in SLTA scores, similarly to Factor 1. However, Factor 2 had a negative correlation with the "difficulty" of SLTA, CADL short form, and RCPM scores at the beginning of speech therapy. This indicated that Factor 2 showed a tendency to improve when the scores of these initial evaluations were lower. In addition, this factor tended to improve more with age. These results suggest that the SLTA sub-test scores related to comprehension are relatively low in difficulty, and the improvement scores tend to be clear only in cases with low scores at the initial evaluation due to the ceiling effect. Furthermore, it is considered that the initial evaluation of comprehension is stricter as the initial scores on the SLTA, the CADL short form, and the RCPM are lower and decreased as the patients aged. It is evident that in-depth tests are necessary to more precisely understand patients' improvement of language function as it is related to comprehension.

Factor 3: "The oral reading improvement factor" was also an important factor that contributed to the improvement of the SLTA general score. It improved due to the sum of all subtest scores of the SLTA being lower at the beginning. We concluded that oral reading function is likely to be impaired early in the disease and improved with speech therapy.

Factor 4: "The word enumeration improvement factor" improved as the initial scores on the SLTA and CADL short form were high and did not show a correlation with the general improvement of the SLTA score. We concluded that this factor was difficult to improve if the initial aphasia was severe and the improvement was independent from the overall improvement in aphasia. In previous studies,[3,4] this item was included, "The core factor of improvement in recovery from aphasia." It was unexpected that this item was extracted as an independent factor, especially separate from the item of visual confrontation naming. It was previously observed that the responsible lesion of the self-relevant word enumeration disorder is different from that of the naming disorder.[9] It was suggested that improvements in word enumeration and naming are different, and that it will be necessary to design a separate study for each to more accurately observe, measure, and evaluate improvements in speech therapy. Future studies are warranted that focus on the mechanisms that will elucidate the differences in improvement between these.

Factor 5: "The repetition improvement factor" did not correlate with any of the subjects' characteristics. This result was similar to those in our previous studies,[3,4] and it could be considered that no matter how much repetition improved, it did not lead to improvements in overall aphasia, which is consistent with the impression we received in patients' improvements with speech therapy.

Factor 6: "The intelligence improvement factor" improved as the initial CADL short form and RCPM scores were lower. It was confirmed that there was a correlation between the patients' scores on the initial CADL short form and those on the RCPM (Table 4). It was revealed that the lower the initial scores, the greater the range of improvements. Moreover, improvement in intelligence did not correlate with the general improvement of the patients' SLTA scores, and it was also confirmed from these results that the improvement in language function and intelligence were independent. This is the only factor that showed a correlation in education level, suggesting that higher education may promote improvement in intellectual function.

The number of clinical experience years of the ST in charge of the patient did not correlate with any improvement factors. However, an interesting trend was observed in the correlations among the subjects' characteristics (Table 4). It was found that the shorter the ST's clinical experience, the higher the patient's initial CADL short form score, and the patient's age of 75 or younger was lower. This was considered to be the result of the implicit consideration that less experienced STs were responsible for younger, mildly disabled patients who were clinically less complex. With such clinical considerations, it may have been possible to prevent significant differences in aphasia improvement depending on the years of experience of the STs.

In our previous studies,[3,4] we repeatedly proposed that a program for the essential improvement of aphasia must include training that improves patients' spontaneous outputs such as visual confrontation naming and writing confrontation naming, and improves complex language information processing such as syntax and calculations in speech therapy. The essential improvement of language function was found to be directly linked to the improvement of functional communication ability in daily life in the present study. Furthermore, we found that the structure for improving non-linguistic intelligence is different from that for improving linguistic function and communication ability in daily life. This study provides some perspectives that can serve as a reference for the

speech therapy of aphasia during the recovery period based on evidence-based practice.

**Conflicts of Interest:** None

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