Effects of Semantic Treatment on Verbal Communication and Linguistic Processing in Aphasia After Stroke
A Randomized Controlled Trial

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Background and Purpose—Semantic deficits, deficits in word meaning, have a large impact on aphasic patients’ verbal communication. We investigated the effects of semantic treatment on verbal communication in a randomized controlled trial.

Methods—Fifty-eight patients with a combined semantic and phonological deficit were randomized to receive either semantic treatment or the control treatment focused on word sound (phonology). Fifty-five patients completed pretreatment and posttreatment assessment of verbal communication (Amsterdam Nijmegen Everyday Language Test [ANELT]). In an on-treatment analysis (n=46), treatment-specific effects on semantic and phonological measures were explored.

Results—Both groups improved on the ANELT, with no difference between groups in overall score (difference, −1.1; 95% confidence interval [CI], −5.3 to 3.1). After semantic treatment, patients improved on a semantic measure (mean improvement, 2.9; 95% CI, 1.2 to 4.6), whereas after phonological treatment, patients improved on phonological measures (mean improvement, 3.0; 95% CI, 1.4 to 4.7, and 3.0; 95% CI, 1.2 to 4.7).

Conclusions—No differences in primary outcome were noted between the 2 treatments. Our findings challenge the current notion that semantic treatment is more effective than phonological treatment for patients with a combined semantic and phonological deficit. The selective gains on the semantic and phonological measures suggest that improved verbal communication was achieved in a different way for each treatment group. (Stroke. 2004;35:141-146.)

Key Words: aphasia ■ linguistics ■ randomized controlled trials ■ rehabilitation ■ semantics

Aphasia is present in about a quarter of all stroke patients and has a large impact on their quality of life. Treatment may be focused on the language deficit itself, on compensatory strategies, or on using residual skills in communication. With regard to treatment focused on the language deficit, the cognitive linguistic approach was recently recommended as a practice standard.1 Cognitive linguistic treatment aims to improve processing at the affected linguistic level, eg, semantics (word meaning), implicitly assuming that training of basic language skills will result in improved verbal communication.

Semantic treatment is widely used for remediation of word-finding deficits in aphasic communication and is reported to be more effective than phonological treatment (word sound).2,3 Well-designed case and small-group studies showed encouraging positive results of semantic treatment on picture naming.2,4,5 However, this finding does not necessarily imply improved everyday communication.

Improvement of verbal communication (Amsterdam Nijmegen Everyday Language Test [ANELT])6 was found in our first study, a multiple case study with a crossover design.7 Half of the patients, who were all >1 year postonset, improved after semantic treatment (BOX),8 whereas none improved after phonological treatment. These findings encouraged us to evaluate the effect of BOX on verbal communication in a randomized controlled trial.9

The present study investigates the efficacy of BOX in the period when Dutch patients normally receive treatment, 3 to 12 months after onset. Because it would be impossible to find patients willing to take the chance of not receiving treatment in this period, we used FIKS10 as a control condition. This treatment is within the cognitive linguistic approach, like BOX, but focuses on a different linguistic level, phonology. Our hypothesis was that semantic treatment would have a greater effect on everyday language than phonological treat-
ment. In addition, we analyzed the effects of both treatments on specific semantic and phonological measures.

Subjects and Methods
This study is an observer-blinded randomized controlled trial, reported according to the Consolidated Standards of Reporting Trials statement.11 The allocation sequence was computer generated and concealed in sequentially numbered, opaque, sealed envelopes until randomization. The experimental group received semantic treatment (BOX); the control group received phonological treatment (FIKS). Treatment was given by the speech and language therapist who referred the patient. Researchers carried out the assessment.

Subjects
Speech and language therapists from 35 Dutch clinical centers referred stroke patients with aphasia (age, 20 to 85 years) for assessment and possible inclusion. Therapists were asked to refer patients whom they considered candidates for an intensive treatment program, taking into account practical, psychological, physical, and cognitive factors. They were asked not to refer illiterates, nonnative speakers, or patients with dysfloria, developmental dyslexia, severe (in relation to aphasia) acquired dyslexia, or a visual perceptual deficit. Furthermore, patients with “global aphasia” or “recovered or no aphasia” (Aachen Aphasia Test [AAT][12] classification) were excluded. To minimize the effect of spontaneous recovery, patients were not included before 3 months after onset. For inclusion and diagnosis, the AAT was administered, with the Token Test as a measure of severity. The presence of a moderate or severe verbal communicative deficit (ANELT <36/50) was established. Only patients with both a semantic and a phonological deficit were included, ensuring that both groups received relevant treatment.

Criteria for a semantic deficit were (1) at least 1 of the following semantic tasks below cutoff: Semantic Association Test (SAT),13 Synonym Judgment (Psycholinguistic Assessment of Language Processing in Aphasia [PALPA]),14 Semantic Word Association of low imageability words (PALPA), and (2) AAT-Comprehension below cutoff.

Criteria for a phonological deficit were (1) AAT-Repetition <125/150 and (2) AAT-Repetition or AAT-Naming >50% of the errors contained phonological distortions.

To control for cognitive variables that might influence treatment efficacy, 2 measures of recognition memory (word recognition from the Consortium to Establish a Registry for Alzheimer’s Disease [CERAD])15 and object recognition from the Rivermead Behavioral Memory Test, RBMT16) and a measure of executive functioning (Weigl Sorting Test)17 were administered.

Informed written consent was obtained from all patients or close relatives. The local Medical Ethics Committee approved the study.

Treatment
Treatment started at 3 to 5 months after onset and lasted until 10 to 12 months after onset. Treatment was comprised of 40 to 60 hours of individual treatment (1.5 to 3 hours a week in 2 or 3 sessions). Besides the assigned language treatment, no other language treatment was allowed. Therapists were experienced professionals trained to work with the allocated treatment program in regular workshops and in an individual session with the patient. They were trained to work as “purely” as possible; eg, for semantic treatment, patients were discouraged to read the words aloud, and for phonological treatment, no semantic cues were allowed.

BOX, the semantic treatment, is focused on the interpretation of written words, sentences, and texts. BOX contains a variety of semantic decision tasks aimed at enhancing semantic processing. Exercises are in multiple choice or right/wrong format and have several levels of difficulty. Factors influencing difficulty are the number of distracters, the strength of the semantic relation, and the frequency and abstractness of the word. There are 8 subparts with >1000 exercises: semantic categories, syntagmatic and paradigmatic relationship, semantic gradation, adjectives and exclamations, part-whole relationship, anomalous sentences, semantic definitions, semantic context.

FIKS, the phonological treatment, is focused on sound structure. As in BOX, written exercises on the word, sentence, and text level are presented, directed at the phonological input and output routes. There are 10 subparts with several levels of difficulty with >1000 exercises: rhyming, consonant clusters, stress patterns, compiling words, word length, phonemic similarity, texts, phonetics and syllabification, homophones, analysis and synthesis.

Outcome Measures
The primary outcome measure was the ANELT, scale A (understandability), a valid and reliable measure of verbal communicative ability.19 Verbal responses in 10 everyday language scenarios are scored on a 5-point scale for informational content. Patient responses were tape recorded and scored by 2 independent observers blinded to test moment (pretreatment or posttreatment) and treatment allocation. The mean of the 2 observers’ scores was used in the analyses. Agreement between judges was assessed by means of a plot of the difference between the scores against their mean. Furthermore, the mean difference between judges, with 95% confidence interval (CI) was calculated.

The specific semantic measures used were the SAT in which the patient chooses from 4 written words (the target, 2 semantically related words, and an unrelated word) the word that is semantically closest to a given word, and synonym judgment (PALPA) in which the patient judges whether 2 written words are synonyms. The specific phonological measures used were repetition nonwords (PALPA) and auditory lexical decision (PALPA) in which the patient decides whether a heard “word” is a real word or not.

Statistical Analysis
The final score and mean improvement of both groups on the ANELT were compared by means of an independent-sample t test. Results are expressed as the difference in improvement between the 2 groups with 95% CI. We planned to adjust for differences in confounding variables thought to influence the efficacy of the treatment (age, sex, handedness, severity, type and location of lesion, type and severity of aphasia, time since onset, amount of treatment, memory, and executive functioning) using multiple linear regression analysis.

The percentage of patients in each treatment group that improved more than the clinically significant difference (≥8 points)6 on the ANELT was compared by means of a χ² test. In addition, ANELT scores were categorized into severe (score, 10 to 29) and moderate to mild (score, 30 to 50) communication deficits. The percentage of patients in each treatment group that fell into the moderate to mild category after treatment was compared by means of a χ² test.

Analyses were performed for both the intention-to-treat groups and the on-treatment groups. The intention-to-treat analysis included all patients for whom an ANELT score was obtained both before and after treatment. For the on-treatment analysis, only patients who had had at least 40 hours of treatment were included. For the on-treatment groups, improvement on phonological (repetition nonwords, auditory lexical decision) and semantic measures (SAT, synonym judgment) was also investigated. Improvement on these measures was compared by means of an independent-sample t test. Results are expressed as the mean difference between groups and 95% CI. Pearson correlations were computed between improvement on semantic or phonological measures and improvement on the ANELT in each on-treatment group.

It was estimated that a sample of 60 patients would provide 80% power to detect a critical difference of 8 points on the primary outcome measure (ANELT) between the 2 treatment groups at a 5% 2-sided significance level.

Results
At the end of the inclusion period, 87 patients had been referred. Of these, 58 patients entered the study, and 29 were not included because, after assessment, they appeared not to
fulfill the criteria for a semantic and/or phonological deficit and/or did not have a moderate to severe verbal communicative deficit. The groups did not differ with respect to sex, handedness, time since onset, type and location of lesion, type of aphasia, severity of aphasia (AAT Token Test), ANELT score pretreatment, tests for memory and executive function, or amount of treatment received. However, patients receiving semantic treatment were on average 8 years older than patients who received phonological treatment (Table 1).

No posttreatment scores could be obtained for 3 patients: 1 patient was missed, and 2 patients refused. Of the intention-to-treat patients, 9 of 55 received <40 hours of treatment (range, 8 to 30 hours) for various reasons. Their posttreatment assessment occurred at the time of treatment discontinuation. These patients were not included in the on-treatment analyses. An independent neurologist blinded to the test results and the treatment allocation excluded another 3 patients from the on-treatment analyses because of dementia, depression, and severe illness at the time of posttreatment assessment (the Figure).

A plot of the difference in ANELT scores between the 2 independent observers against the mean ANELT scores suggested acceptable agreement between them. There was no obvious relation between the difference and the mean. The mean difference in ANELT score was 0.82 (95% CI, 0.09 to 1.55).

### Intention-to-Treat Analyses

After treatment, the mean ANELT score improved significantly for both the semantic and phonological groups. No significant difference between the treatment groups was found for either final scores or mean improvement in ANELT scores (Table 2).

### Table 1. Baseline Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Semantic Treatment (n=29)</th>
<th>Phonological Treatment (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (SD), y</td>
<td>66 (10)</td>
<td>58 (14)</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>18 (62)</td>
<td>15 (52)</td>
</tr>
<tr>
<td>AAT classification, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wernicke</td>
<td>14 (48)</td>
<td>15 (52)</td>
</tr>
<tr>
<td>Broca</td>
<td>11 (38)</td>
<td>7 (24)</td>
</tr>
<tr>
<td>Anomic</td>
<td>2 (7)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (7)</td>
<td>5 (17)</td>
</tr>
<tr>
<td>Time since stroke at inclusion (mean), mo</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Stroke origin, n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infarction</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Location of stroke (left hemisphere), n</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>Handedness (EHI), n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>Left</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Ambidextrous</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mean amount of treatment (SD), h</td>
<td>42.2 (13.3)</td>
<td>40.4 (14.4)</td>
</tr>
<tr>
<td>Token Test (AAT; maximum=50), mean error score (SD)</td>
<td>33.6 (11.5)</td>
<td>35.3 (10.2)</td>
</tr>
<tr>
<td>Word recognition (CERAD; maximum=10), mean (SD)</td>
<td>5.7 (3.0)</td>
<td>5.6 (3.1)</td>
</tr>
<tr>
<td>Object recognition (RBMT; maximum=10), mean (SD)</td>
<td>9.2 (1.4)</td>
<td>8.7 (2.4)</td>
</tr>
<tr>
<td>Weigl Sorting Test (maximum=15), mean (SD)</td>
<td>5.3 (2.9)</td>
<td>5.0 (2.7)</td>
</tr>
<tr>
<td>ANELT-A (maximum=50), mean (SD)</td>
<td>24.8 (11)</td>
<td>23.3 (8)</td>
</tr>
</tbody>
</table>

EHI indicates Edinburgh Handedness Inventory.29

### Table 2. Comparison of ANELT Score Between Patients Who Were Randomized to Semantic Treatment (n=29) or Phonological Treatment (n=26)

<table>
<thead>
<tr>
<th></th>
<th>Semantic Treatment (n=29)</th>
<th>Phonological Treatment (n=26)</th>
<th>Difference Mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean final score (SD)</td>
<td>29.9 (12)</td>
<td>29.5 (11)</td>
<td>0.4 (−6.0–6.9)</td>
</tr>
<tr>
<td>Mean improvement (SD)</td>
<td>5.1 (9)</td>
<td>6.2 (7)</td>
<td>−1.1 (−5.3–3.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Semantic Treatment (n=23)</th>
<th>Phonological Treatment (n=23)</th>
<th>Difference Mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean final score (SD)</td>
<td>31.3 (12)</td>
<td>30.2 (11)</td>
<td>1.1 (−5.9–8.0)</td>
</tr>
<tr>
<td>Mean improvement (SD)</td>
<td>6.4 (6)</td>
<td>6.5 (7)</td>
<td>−0.1 (−4.0–3.9)</td>
</tr>
</tbody>
</table>
After semantic treatment, 34% of the patients improved significantly ($\geq 8$ points), whereas after phonological treatment, 35% improved significantly (relative risk, 1.00; 95% CI, 0.68 to 1.47). Fifty-nine percent had a moderate to mild communication deficit after semantic treatment (ANELT score >29) compared with 54% after phonological treatment for a relative risk of 0.90 (95% CI, 0.40 to 2.01). Adjustment for age by multiple linear regression analysis did not change the effect.

**On-Treatment Analyses**

In the on-treatment analysis, the mean ANELT score also improved significantly for both groups. Again, no significant difference between the treatment groups was found when final ANELT scores and mean improvement were compared (Table 2). The percentage of patients who showed a clinically significant improvement ($\geq 8$ points) was 39% after semantic treatment compared with 35% after phonological treatment for a relative risk of 0.93 (95% CI, 0.84 to 1.01). The percentage of patients who had a moderate to mild communication deficit was 65% after semantic treatment compared with 52% after phonological treatment for a relative risk of 0.73 (95% CI, 0.36 to 1.47).

Treatment-specific effects were found at the impairment level. After semantic treatment, patients improved significantly on a semantic measure (SAT). After phonological treatment, patients improved significantly on the phonological measures (repetition nonwords, auditory lexical decision). After phonological treatment, improvement on a phonological measure (ie, auditory lexical decision) was larger than improvement after semantic treatment. However, improvement after semantic treatment on a semantic measure was larger, but not significantly so, than after phonological treatment (Table 3).

Improvement at the impairment level was related to improvement on the ANELT. In the semantic group, there was a correlation with 1 of the semantic measures (SAT), whereas in the phonological group, there was a correlation with 1 of the phonological measures (repetition nonwords) (Table 4).

**Discussion**

This study is the third randomized controlled trial in which a specific aphasia treatment method was evaluated. It is the first that is applied to a homogeneous group of patients whose linguistic deficits are specified and that uses an outcome measure of verbal communication.

After semantic treatment, patients with a combined semantic and phonological deficit improved on the ANELT, a measure with strong ecological validity. However, control patients who received phonological treatment improved to a similar degree, refuting our hypothesis that semantic treatment has more effect at the activities level (verbal communication) than phonological treatment.

At the impairment level, patients improved on a semantic measure after semantic treatment and on phonological measures after phonological treatment. Moreover, in both treatment groups, therapy-specific correlations between improvement on the ANELT and improvement on semantic versus phonological measures were found. These specific effects challenge the interpretation that the equal improvement in verbal communication in both groups is a result of spontaneous recovery. Moreover, Laska et al found no progress on the ANELT after 3 months postonset in an unselected group of 119 patients. All patients entered our study after 3 months

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**TABLE 3. Progress of On-Treatment Groups on Semantic and Phonological Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Semantic Treatment</th>
<th>Phonological Treatment</th>
<th>Mean Difference Between Treatment Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT (max=30)</td>
<td>2.9 (1.2–4.6)*</td>
<td>1.6 (–0.2–3.3)</td>
<td>1.3 (–1.0–3.7)</td>
</tr>
<tr>
<td>Synonym judgment (max=60)</td>
<td>1.7 (–1.1–4.5)</td>
<td>0.1 (–2.3–2.4)</td>
<td>1.6 (–1.9–5.2)</td>
</tr>
<tr>
<td>Repetition nonwords (max=24)</td>
<td>1.3 (–1.2–3.7)</td>
<td>3.0 (1.4–4.7)*</td>
<td>–1.7 (–4.6–1.1)</td>
</tr>
<tr>
<td>Lexical decision (max=80)</td>
<td>–0.5 (–2.9–1.7)</td>
<td>3.0 (1.2–4.7)*</td>
<td>–3.5 (–6.3–0.7)*</td>
</tr>
</tbody>
</table>

*Significant difference (P<0.05).

**TABLE 4. Correlations of Improvement on ANELT With Improvement on Semantic and Phonological Measures in Each Treatment Group**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Semantic Treatment</th>
<th>Phonological Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT (max=30)</td>
<td>0.58 (0.01)*</td>
<td>0.40 (0.06)</td>
</tr>
<tr>
<td>Synonym judgment (max=60)</td>
<td>0.34 (0.13)</td>
<td>0.16 (0.51)</td>
</tr>
<tr>
<td>Repetition nonwords (max=24)</td>
<td>0.04 (0.86)</td>
<td>0.58 (0.01)*</td>
</tr>
<tr>
<td>Lexical decision (max=80)</td>
<td>0.24 (0.29)</td>
<td>0.15 (0.50)</td>
</tr>
</tbody>
</table>

*Statistically significant difference (P<0.05).
postonset. The different effects found at the impairment level also suggest that each treatment achieved improvement at the activities level (verbal communication) in a different way, not merely as a result of nonspecific effects such as being engaged in language exercises, receiving attention, or being stimulated.

In early influential studies, the effect of phonological techniques was found to be short lived and restricted to trained items, whereas semantic techniques brought about lasting and generalized improvement. The superior effect of semantic treatment was in line with predictions made by the leading serial models of language processing. The use of phonological techniques is still deemed less effective by some, despite some recent studies showing positive effects of phonological treatment. Because both treatment groups showed equal improvement in our study, we conclude that phonological treatment has suffered undue neglect.

In our previous study, phonological treatment did not result in improved verbal communication. The phonological treatment we then used was felt to be less challenging than FIKS, the treatment we developed for the present study, in terms of variation of the exercises and degrees of difficulty. An additional factor is that patients in the present study received at least twice the amount of treatment (40 to 60 hours) compared with those from the previous study.

Apparently, for patients with both deficits, phonological treatment is potentially as effective for improving verbal communication as semantic treatment. These results ask for new research aimed at the efficacy of modifications of the therapies used in this study (eg, semantic and phonological treatment in a mixed format or one after the other), the optimal timing of treatment (perhaps early after onset), the intensity of treatment, and the efficacy of BOX and FIKS in patients with selective semantic or phonological disorders.

To firmly establish that the observed effects were induced by the treatments used, one should also run a controlled study comparing no treatment to phonological and/or semantic treatment.

The ethical dilemma of giving no treatment to aphasic patients could be bypassed by delaying treatment to the control group or by providing control patients with a low-intensity treatment schedule. This design is chosen for our next trial, in which the efficacy of semantic treatment will be investigated in patients 0 to 3 months after onset. Investigating whether lesion location modifies the treatment results was not feasible for the present trial but may be included in the next.

Finally, although our results do not unequivocally prove the efficacy of either treatment, the treatment-specific effects we found at the impairment level suggest that there may be 2 routes that lead to improved verbal communication: a semantic route and a phonological route. Linguistic analysis of ANELT responses, which is currently carried out, may support this notion if a qualitatively different progress in verbal communication is found in both groups.

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