Assessment and treatment of linguistic deficits in aphasic patients

Assessment and Treatment of Linguistic Deficits in Aphasic Patients

Diagnostiek en behandeling van linguïstische stoornissen bij patiënten met afasie

Proefschrift

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List of Abbreviations

ANELT	Amsterdam-Nijmegen Everyday Language Test
PALPA	Psycholinguistic Assessment of Language Processing in Aphasia
SAT	Semantic Association Test
AAT	Aachen Aphasia Test
CI	Confidence Interval

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Introduction

Aphasia and word finding problems

Aphasia is a language disorder that is caused by brain damage in the dominant hemisphere, i.e. the left hemisphere in all right-handed people and in about half of the left-handed. The most common cause (80%) is a stroke.

In patients with aphasia, all language modalities may be disturbed, i.e. speaking, understanding, writing and reading. One of the main problems almost all aphasic patients experience in everyday communication is word finding problems. Because of their large impact on the quality of conversational speech, reduction of word finding problems is one of the main goals in treatment. Difficulties in word retrieval may manifest themselves by hesitations or a lack of response, or by one of the following errors:

- semantic paraphasias: errors in word-meaning; often words are selected that have semantic features in common with the target (e.g. apple instead of pear)
- phonological paraphasias: errors in word-form, i.e. in the selection and sequencing of word sounds (tear, or a non-existent word like kear, instead of pear)
- neologisms: unintelligible words (saggel)
- superordinates and generalisations: e.g. fruit or thing instead of pear
- circumlocutions, e.g. something you can eat, it grows on a tree
- recurring utterances: repetitive sounds words or phrases, e.g. du.du.du.; I'm a stone, I'm a stone (Code, 1982)

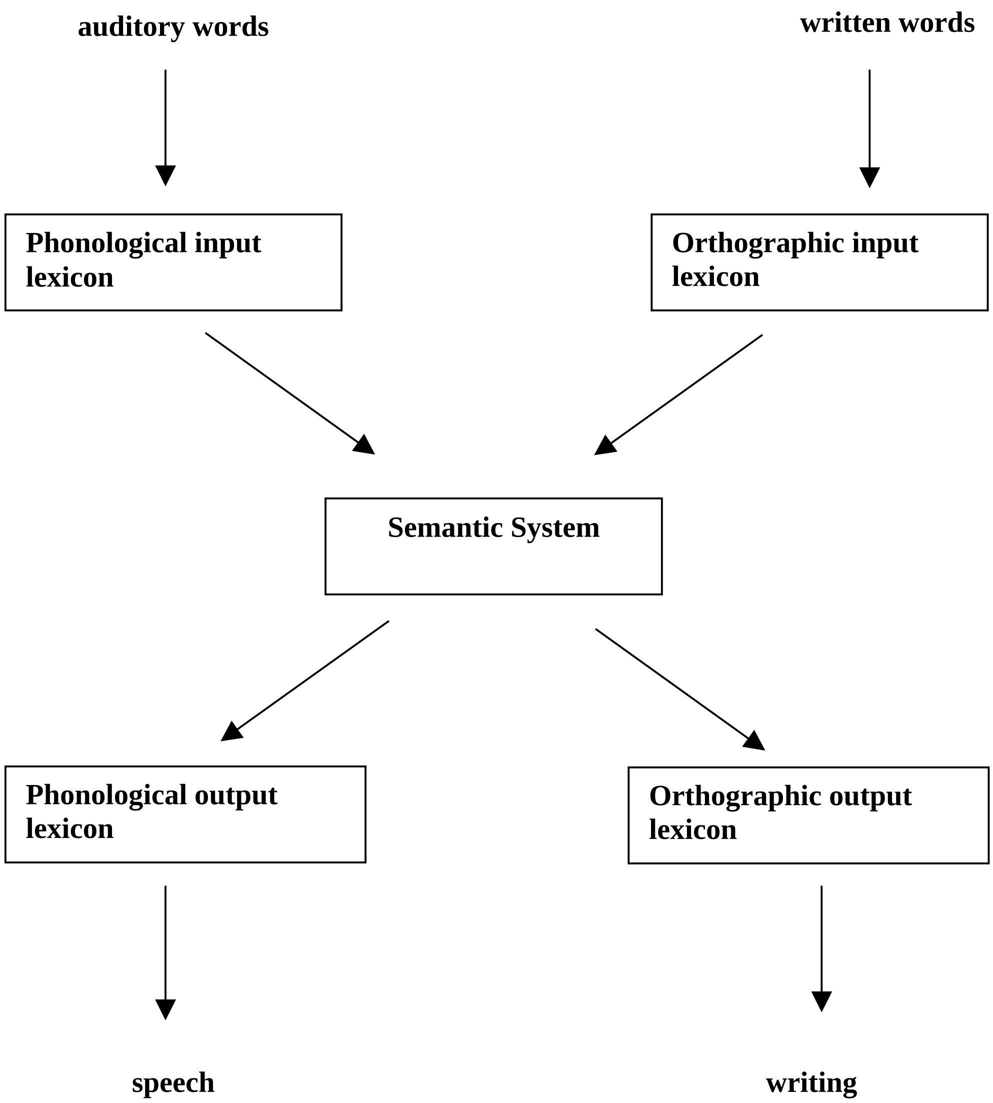
The way in which wordfinding problems are expressed, i.e. the errors aphasic patients make, plays an important role in classification into different aphasia types. Patients whose speech is littered with semantic and phonological paraphasias, neologisms and generalisations are classified as Wernicke's aphasia. In patients with Broca's aphasia some phonological paraphasias and omissions are observed. In patients with anomic aphasia, wordfinding problems are mainly expressed by pauses, circumlocutions and self-corrections. Conduction aphasia is characterised by speech with many phonological paraphasias and conduite d'approche. In patients with global aphasia, if they speak at all, speech is restricted to recurring utterances or neologisms with occasionally an existing word.

Though this classification is useful for shorthand communication with colleagues, it does not provide sufficient information to plan treatment, as classification is based on overt symptoms, not on the linguistic deficits underlying these symptoms.

Cognitive neuropsychological approach

A diagnosis based on the cognitive neuropsychological approach is more informative for guiding treatment. This approach is based on the notion that a specific aphasic sign or symptom may be the apparent clinical manifestation of different underlying deficits within the cognitive structure of language. The deficits are described in terms of defective access to or damage of modules or connections between modules. The model described by Ellis & Young (1988) (based on Patterson & Shewell, 1987) is a model for language processing of single words. It specifies a central semantic system, connected with separate stores for phonological (oral) and orthographic (written) word forms for both comprehension and expression. See figure 1 for a simplified version of this model.

Figure 1. Simplified version of the language model by Ellis & Young (1988)



The semantic system contains all the features (perceptual properties, functions etc.) that together make up the meaning of a word, e.g. for the word ‘apple’ it will contain the features ‘green, hard, food, fruit, tasty, healthy’. A deficit in the centrally located semantic system will result in semantic errors (errors in word meaning) in the production and the comprehension of spoken and written words. Patients who make semantic errors in oral production, but not in comprehension of spoken and written words do not have a central semantic deficit: their deficit is likely to be located peripherically, in the phonological output lexicon (the store for phonological word forms) or in the connection from the semantic system to the phonological output lexicon (Hillis & Caramazza, 1995). This shows how the same aphasic symptom (semantic paraphasias) may arise from different underlying deficits.

Assessment

linguistic deficits
There are several tests available for assessing linguistic deficits. Commonly used lexical semantic tests are tests in which a written or spoken word has to be matched with one of several pictures, one of which represents the word (e.g. parts of the Psycholinguistic Assessment of Language Processing in Aphasia [PALPA], Kay, Lesser, & Coltheart, 1992). Other examples are association tasks, in which the word is to be matched with a word that is semantically related to the target (Semantic Association Test, Visch-Brink & Denes, 1993, see figure 2) or tasks in which the patient decides whether two words are synonyms or not (e.g. money – coin, money – dwarf, PALPA 48). Furthermore, the presence and severity of the semantic deficit may be assessed by analysing error-types (semantic paraphasias) in spontaneous speech or during a naming task. Phonological tests are for example repetition tasks or reading aloud words and nonwords for deficits in the output-route, and discrimination of minimal pairs or lexical decision for deficits in the input-route (e.g. parts of the PALPA). Analysis of spontaneous speech or performance on a naming task for presence of phonological paraphasias may be used as well.

verbal communication
Linguistic deficits may have a large impact in everyday communicative situations. It is hard to predict the level of communicative disability from performance on semantic and phonological tests alone: the relationship between linguistic deficits (‘the impairment level’ in terms of the World Health Organisation, WHO, 2001) and communication deficits (‘the level of activities limitations’) is relatively unexplored (see the study presented in chapter 3). Therefore direct assessment of communicative ability is to be preferred. A valid and reliable measure for assessing verbal communicative ability is the Amsterdam Nijmegen Everyday Language Test (ANELT, Blomert, Koster, & Kean, 1995), scale A. The test comprises 10

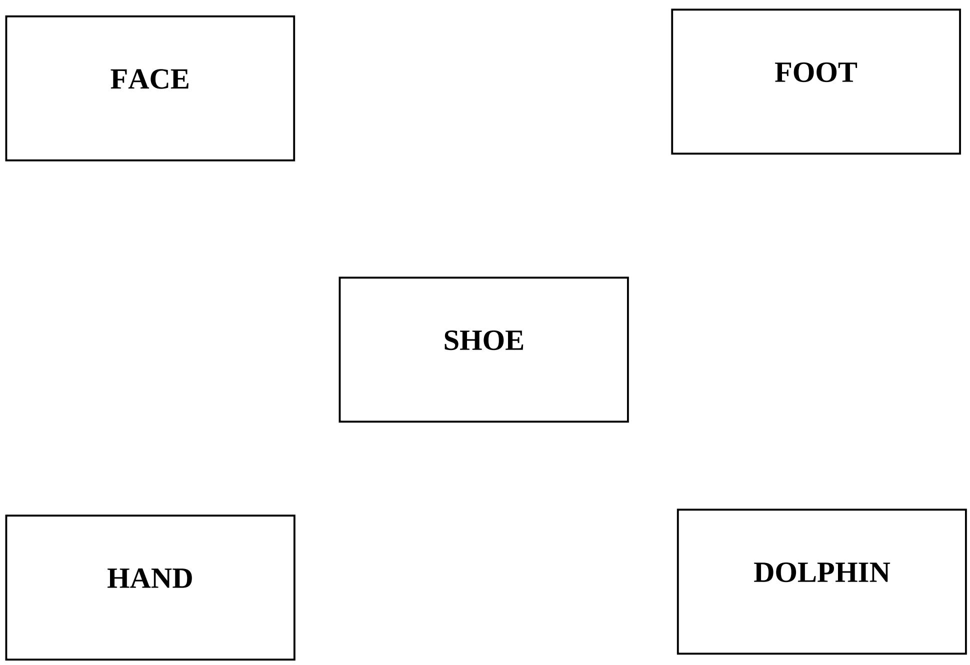
situations presented to the patient. The patient's verbal response is scored on a 5-point rating scale for informational content.

Example of an ANELT-item "Your neighbor's dog is barking all day. It is really bothering you. You go up to him and say…"

A patient's response "That one, that one can also be quiet, can also make less noise. Neighbor, lock him away in the garage or something."

Figure 2. Example of test item

"Which word is most closely related to the word in the middle?"
Semantic Association Test. Visch-Brink, E.G., Stronks, D.L. & Denes, G. Lisse: Swets & Zeitlinger (in press).



Recovery of post stroke aphasia

About a quarter of all patients with a stroke have aphasia in the first week post onset (Wade, Hewer, David, & Enderby, 1986; Pedersen, Jorgensen, Nakayama, Raaschou, & Olsen, 1995; Thomessen, Thoresen, Bautz-Holter, & Laake, 1999; Laska, Hellblom, Murray, Kahan, & Von Arbin, 2001), which means that about 5000 new cases per year occur in the Netherlands. Of all patients with aphasia after stroke, about one third of survivors has recovered at one year post stroke. Most spontaneous recovery occurs in the first three months (Pedersen et al., 1995). Relatively little is known about which aspects of the language disorder are particularly resistant to recovery. A few studies investigated aphasic symptoms like auditory comprehension and expression and some of these found that auditory comprehension recovered sooner and more complete than expression (e.g. Kertesz, 1984). So far, the recovery of the underlying linguistic deficits has not been studied.

Treatment of aphasia

The patients who do not recover completely often experience serious difficulties in everyday communicative situations, which greatly influence their quality of life. In terms of the WHO, their impairments (e.g. semantic or phonological deficits) result in activities limitations (communicative disability) and participation limitations (e.g. loosing a job). The ultimate goal of aphasia treatment is to improve these patients' communicative ability in daily life. This may be approached in several ways, with a focus at the "impairment level" or at the "activities limitations level".

Impairment level

For many patients restitution of linguistic functions will be attempted by means of "impairment oriented" treatment; treatment is focused on the linguistic deficits that underlie the communicative problems. By means of model-oriented assessment (i.e. assessment guided by a language model like the one presented here), the functions that need to be modified or circumvented can be identified, e.g. semantic processing or phonological processing. Based on cognitive theories, several impairment oriented treatments have been developed. Examples of treatments at the wordlevel are semantic treatment and phonological treatment.

Semantic treatment comprises exercises that stimulate the patient to activate semantic features of words. Examples are: word-picture-matching tasks, yes/no questions (is a cow an animal?), categorisation (sorting words in categories, e.g. fruit and vegetables), producing antonyms and synonyms (e.g. Nettleton & Lesser, 1991; McNeil et al., 1997). These types of tasks may influence changes at the level of the semantic system, which will be reflected in improved wordfinding abilities and comprehension.

Phonological treatment comprises exercises that train the selection and sequencing of speech sounds. Examples are repetition, reading aloud, picture naming with a phonological cueing hierarchy (e.g. the therapist provides the patient with the first sound, the first syllable or the whole word for repetition) or rhyme judgment (e.g. "do *cat* and *bat* rhyme?")(Miceli, Amitrano, Capasso, & Caramazza, 1996; Raymer, Thompson, Jacobs, & le Grand, 1993).

In the Netherlands, two treatment programs with a large amount of exercises at word, sentence – and text level at different levels of difficulty have been developed: BOX (Visch-Brink & Bajema, 2001), a semantic treatment and FIKS (Van Rijn, Booy, & Visch-Brink, 2000), a phonological treatment. See appendix for examples of exercises from BOX and FIKS. The efficacy of these treatment programs has never been assessed in a controlled clinical trial.

With semantic and phonological treatment, the main therapeutic goal is the restitution of cognitive function (e.g. semantic processing). However, there are also approaches at the impairment level that are not primarily aimed at recovery of a cognitive function, but at compensation or reorganisation. An example of such an approach is the treatment program Multicue, that teaches the patient strategies to cue themselves when experiencing wordfinding problems. The efficacy of such a program has not been established in a group study.

Activities limitations level

Instead of aiming at restitution or compensation of a cognitive function, aphasia treatment may be focused on developing alternative, compensatory strategies for communication, for example by stimulating the patient to write, draw or use gestures to get the message across, as in PACE (Carlomagno, 1994).

Therapeutic research in aphasia

Robey & Schultz (1998) present a model of clinical outcome research, which they adapted for aphasia treatment. In phase 1 and 2 one patient or a few patients are shown to improve following a certain treatment. Furthermore, it is decided for which aphasic patients the treatment would be suitable, the treatment procedures are defined and the measures with which improvement is to be assessed are selected.

In phase 3, efficacy of the treatment is tested in a clinical trial. A randomized controlled trial is usually taken to be the most robust methodology for assessing the effectiveness of an intervention.

Wordfinding treatment, phase 1 and 2 studies

Single case and small group-studies have investigated the efficacy of both semantic and phonological treatment. These studies cover a variety of patients, treatment tasks and outcome-measures. 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 (Howard, Patterson, Franklin, Orchard-Lisle, & Morton, 1985). The superior effect of semantic treatment was in line with predictions made by the leading serial models of language processing, like the one presented here. As the semantic system is located in the center of the model, it affects all modalities: understanding spoken and written language as well as speaking and writing. The measure that was most often selected to investigate improvement was performance on a picture naming task.

Phase 3 studies

Though many phase 1 and 2 studies have investigated cognitive linguistic treatment, phase 3 studies (randomized controlled trials) in aphasiology are scarce. This may be partly because a large numbers of patients must be recruited to trials, which requires considerable use of resources. Furthermore, as nowadays most patients with aphasia receive treatment, some would consider it unethical to withhold treatment to the patients assigned to the control group. A Cochrane review of the randomized controlled trials evaluating treatment for patients with aphasia after stroke considered only 12 studies eligible for the review (Greener, Enderby, & Whurr, 2001). In most of these studies, the efficacy of relatively broad-based interventions, for example group-treatment, intensive treatment, or treatment by volunteers was compared with 'standard treatment' or deferred treatment. See table.

Table. Randomized controlled trials in the Cochrane review

Authors	**Experimental treatment**	**Control treatment**
David et al. (1982)	SLT	Volunteers
Leal et al. (1993)	SLT	Volunteers
Meikle et al. (1979)	SLT	Volunteers
Wertz et al. (1986)	SLT	Volunteers
Hartmann & Landau (1987)	SLT	Emotional support by SLT
Wertz et al. (1981)	Group treatment	SLT
Prins et al. (1989)	STACDAP SLT	SLT, No treatment No treatment
Lincoln et al. (1984)	SLT	No treatment
Wertz et al. (1986)	SLT	No treatment
Smith et al. (1981)	SLT Intensive SLT	No treatment SLT, No treatment
Wertz et al. (1986)	Volunteers SLT	SLT, No treatment No treatment
Mackay et al. (1988)	Volunteers	No treatment
Kinsey (1986)	Computer treatment	SLT
Di Carlo (1980)	SLT + filmed instruction	SLT + bibliotherapy, slides, etc.

SLT indicates conventional treatment by a speech and language therapist
STACDAP indicates Systematic Therapy for Auditory Comprehension Disorders in Aphasic Patients

Howard (1986) claims that valid efficacy research requires a specification of the deficit that the treatment intends to remediate as well as a specification of the treatment procedures. In most Cochrane trials, except Prins, Schoonen, & Vermeulen (1989), this is lacking. The conclusion in the Cochrane review was that the lack of statistical power in nearly all the trials means that the question for effectiveness of aphasia treatment remains open.

Bhogal, Teasell, & Speechley (2003) concluded from a meta-analysis of 10 studies, including two nonrandomized controlled trials, that intensive aphasia treatment is probably effective. Other reviews of aphasia treatment that, however, included non-randomized studies, also conclude that aphasia treatment is effective (Whurr, Lorch, & Nye, 1992; Robey, 1994), although some specify that treatment is effective only in specific patients (Enderby, 1996) or with a specific type of treatment (Cicerone et al., 2000).

One can conclude that a) there are indications, but still inconclusive evidence that aphasia treatment is effective and that b) there are few studies that have investigated the efficacy of a well-defined treatment in a well-defined group of patients (van Harskamp & Visch-Brink, 1998).

Objectives and content of this thesis

In this thesis, I present the results of both diagnostic and therapeutic studies in patients with aphasia after stroke.

In *chapter 2*, a newly developed screening test for assessing deficits at the main linguistic levels (semantics, phonology and syntax) is evaluated. As the test is to be used in the acute stage, when patients are often ill and bedridden, it is short and easy to administer. The goal of the new test is to guide early aphasia treatment and to facilitate studies investigating the prognostic value of the presence and severity of semantic, phonological and syntactic deficits in the acute stage.

Chapter 3 discusses the relationship between performance on semantic and phonological tasks and performance on the ANELT-A. We expected a stronger relationship between semantic tasks and the ANELT-A than between phonological tasks and the ANELT-A.

In *chapter 4*, I present the results of a randomized controlled trial comparing the efficacy of semantic and phonological treatment. The principal measure of outcome was the effect of treatment on verbal communication in everyday life, as measured with the ANELT-A. Our hypothesis was that semantic treatment would have more effect on verbal communication than phonological treatment.

Finally, *chapter 5* describes the efficacy of a computerized treatment of wordfinding problems, Multicue, on a naming task and on verbal communicative ability.

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Examples of BOX-exercises

Semantic Categories (the odd one out) forest dunes *flag* plain	**Semantic Definitions** (correct definition?) Freelance A lance carried by horsemen *A person offering services on a temporary basis*
Paradigmatic and Syntagmatic Relations (match with…) bath *shower* sun (help) He got a nice shampoo for his birthday	**Anomalous Sentences** (meaningful sentence?) The ice-cream fights for its life The cook bakes an egg
Part-Whole Relationship (same kind of relationship?) <u>Wings</u> of an airplane flower Christmas tree *bird* *angel* hat	**Adjectives and Exclamations** (meaning of adjective?) Frightened, the cat climbed the nearest tree The cat is brave *The cat is afraid*
Semantic Gradation (match with one of two antonyms) *future* past *tomorrow* souvenir history *prospect* *expectation*	**Context** (anomaly?) Our bakery has developed a new treat: a delicious fruit pie. It consists of our special light dough and fresh fruits. You can pick from six different flavours. The pies are freshly baked in our *laundry* every day. Hurry to our shop and you will only pay £3 for this delicious treat.

Examples of FIKS-exercises

Rhyming (yes or no) fire tire Yesterday we went to the zoo. We saw a beer and a kangeroo We saw a beer and an elephant We saw a beer and a lion	**Compiling words** (make a word) ball feet foot bell
Stress patterns (correct one?) cánary canáry canarý	**Wordlength** (reading aloud / repetition) administration
Consonant clusters (reading aloud / repetition) gutst stram	**Phonemic similarity** (reading aloud / repetition) koevoet slagbal
Texts A Baker basic bales. Case cape. Dame? Fake faces fame.	**Phonetics and Syllabilification** (pronunciation?) kay oz (= chaos) hall oo ween
Homophones (same pronunciation?) hymne ham hill him	**Analysis and synthesis** (word(s) of first phonemes?) (bat, tab) table bell ankle (fill in) .ome

2

Linguistic deficits in the acute phase of stroke

Introduction

There are a number of short aphasia-screening tests that can be used to support clinical judgment, e.g. the Frenchay Aphasia Screening Test (FAST, Enderby, 1987; Al-Khawaja, Wade, & Collin, 1996), the Acute Aphasia Screening Protocol (AASP, Crary, Haak, & Malinsky, 1989) and the Ullevaal Aphasia Screening test (UAS test, Thomessen, Thoresen, Bautz-Holter, & Laake, 1999). These tests are suitable for use in the hospital: they are short (5-15 minutes) and do not require extensive test material at the bedside. The screening tests are developed for determining the presence of aphasia, but often more detailed information is required. For shorthand communication with colleagues, it may be useful to specify aphasia type (e.g. Wernicke, Broca). However, there is growing evidence that a diagnosis in terms of affected linguistic levels -semantics (word meaning), phonology (word sound), syntax (grammatical structure)- is more useful than aphasia type (Howard & Patterson, 1989). A linguistic profile of the patient is needed for adequate referral and for guiding aphasia therapy: the practice standard for the treatment of patients with aphasia following left hemisphere stroke is cognitive linguistic therapy (Cicerone et al., 2000), i.e. therapy focused on the affected linguistic level(s). Treatment aimed at restoration of function, as in cognitive linguistic therapy, is argued to be especially appropriate in early acute stages, in order to converge with neural recovery (Code, 2001). In addition, it is important that patients and their families are informed about the linguistic pattern of the disorder in an early stage. This information can help them to develop coping strategies in communicative situations as soon as possible.

The ScreeLing (Visch-Brink & Van de Sandt-Koenderman, 2002) was developed as a screening test to measure impairment at the semantic, phonological and/or syntactic level in 15 minutes. In this study, the sensitivity and specificity of the ScreeLing for diagnosing aphasia and linguistic deficits in patients with acute stroke were estimated. The presence and severity of linguistic deficits were described for the patients individually and differences between subtests were computed for the patients as a group.

Methods

Subjects

Patients were recruited from the Rotterdam Stroke Databank, a prospective registry of patients with transient ischemic attack, ischemic stroke or primary intracerebral hemorrhage who are admitted to the Department of Neurology of the Erasmus Medical Center. All patients who were admitted between 1 August 2000 and 1 August 2001 were considered for examination.

Native Dutch speakers who could be assessed between 2 and 11 days post stroke were included. Patients whose symptoms had subsided should have neurological signs on examination, to be included in the study. Patients who were illiterate, mentally retarded or premorbidly demented were excluded, as well as patients who had severe visual or auditory problems.

For the analysis of aphasic patients' subtest-scores, additional stroke patients with aphasia were recruited from a second hospital, the Medical Center Rijnmond Zuid, according to the same inclusion-criteria.

The study was approved of by the local Medical Ethics Committee. All patients gave verbal informed consent prior to their inclusion in the study.

Materials and Methods

The ScreeLing consists of three subtests –Semantics, Phonology and Syntax- of 24 items each (see appendix). Its sensitivity and specificity in detecting aphasia were determined by comparing the ScreeLing overall-score with a combined reference diagnosis. The reference diagnosis consisted of three measures, as we considered this to result in a more reliable and valid diagnosis than one that is based on only one measure. Patients were labeled with the reference diagnosis of 'aphasia' if they had aphasia according to at least two of the following measures: a) the 36-item version of the Tokentest (De Renzi E, 1978), an often used and well-validated measure to assess the presence of aphasia, b) the independent judgment of a neurologist (based on clinical examination), c) the independent judgment of a linguist (based on an interview). The linguist and neurologist were blinded to the test results and to each other's judgment. The examiner who assessed the patients with the ScreeLing and the Tokentest, was blind to the judgment of the linguist and neurologist. The ScreeLing was always administered first; the examiner was therefore blind to the Tokentest-score.

The sensitivity and specificity of each ScreeLing subtest (Semantics, Phonology and Syntax) were determined by comparing the subtest-scores of patients with aphasia with the reference diagnosis: the judgment of an experienced linguist. Based on clinical linguistic assessment (not using tasks that were included in the ScreeLing), the linguist decided whether or not the patient had a semantic, phonological and/or syntactic deficit.

Analysis

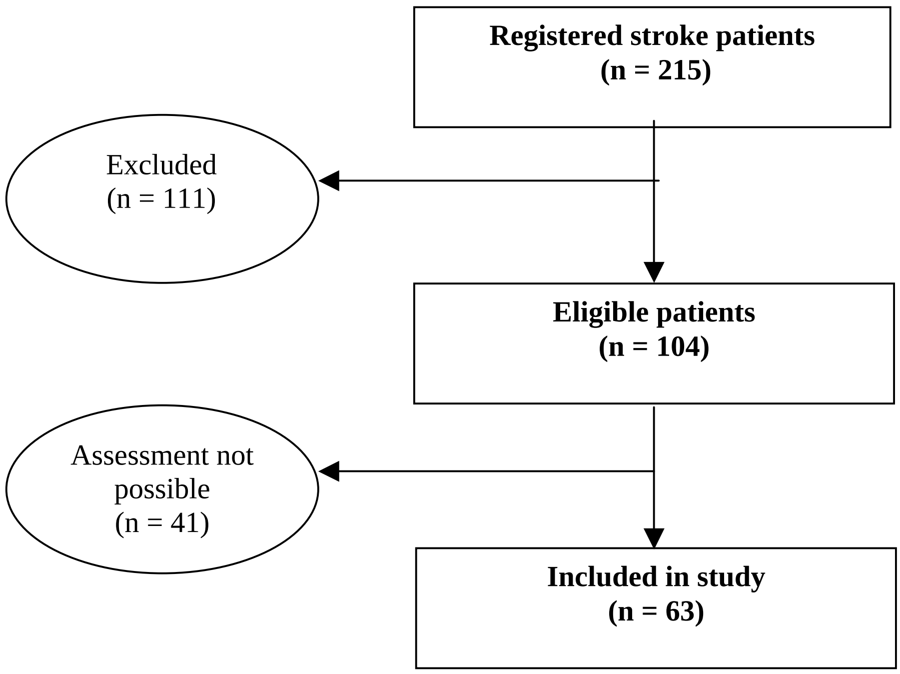
Agreement within the combined reference diagnosis of aphasia was computed. A global assessment of the performance (or diagnostic accuracy) of the ScreeLing and its subtests was given by the area under the Receiver Operating Characteristic (ROC) curve. Sensitivity and specificity at the optimal cut-off point (i.e. maximizing the sum of the sensitivity and specificity) were determined. Differences between mean subtest scores were computed by means of paired samples t-tests.

Results

A consecutive series of 215 patients was recruited from the Rotterdam Stroke Databank (Figure 1). Of these patients, 111 were excluded from the present study, 56 (51%) of whom were not available for testing between 2-11 days post onset due to late admission, early discharge or death, 22 (20%) were non-native speakers, 11 (10%) had a TIA without neurological signs on admission, 10 (9%) had premorbid visual or auditory problems, 6 (5%) refused and 6 (5%) were excluded for other reasons (dementia, mental retardation etc.). One-hundred-and-four patients were included, but 41 (39%) of them could not be assessed due to severe illness (32 patients) or visual-spatial problems (7 patients) or confusion secondary to stroke (2 patients).

A total of 63 patients was assessed. 43 patients were male and 20 were female. Mean age was 62 (sd 16). Most patients (86%) had an infarction. Forty-six percent of the patients had a left hemisphere stroke, 43% a right hemisphere stroke and 11% a brainstem or cerebellar stroke (Table 1).

Figure 1. Flowchart of inclusion of patients[1]



[1] For the subtest analyses, another four patients were recruited from Medical Center Rijnmond Zuid.

Table 1. Baseline characteristics (n = 63)

	aphasia (n = 14)	no aphasia (n = 49)	whole group (n = 63)
Mean age (SD)	68 (11)	60 (17)	62 (16)
Male sex	9 (64%)	34 (69%)	43 (68%)
Location of stroke			
Left hemisphere	13 (93%)	16 (33%)	29 (46%)
Right hemisphere	1 (7%)	26 (53%)	27 (43%)
Cerebellum/brainstem		7 (14%)	7 (11%)
Stroke origin			
hemorrhage	2 (14%)	7 (14%)	9 (14%)
infarction	12 (86%)	42 (86%)	54 (86%)

There was high agreement between the neurologist and linguist (kappa = 0.84, p < 0.01) between the Tokentest and the linguist (kappa = 0.86, p < 0.01) and between the Tokentest and the neurologist (kappa = 0.77, p < 0.01).

ScreeLing overall-score (n = 63)
The median ScreeLing overall-score was 70 out of 72. The optimal cut-off score was 65: patients were classified as aphasic if they scored 65 or less. This resulted in a sensitivity of 86% and a specificity of 96%. The area under the ROC-curve (0.92) indicates that the ScreeLing was an accurate test (Figure 2).

Linguistic levels (n = 17)
Fourteen patients recruited from Erasmus MC had aphasia according to the reference diagnosis, i.e. the Tokentest, the judgment of the neurologist and/or the judgment of the linguist (at least two of these measures). Of one of these patients, the linguistic level reference diagnoses were missing. The other aphasic patients were included into the subtest analyses. Furthermore, four patients with reference diagnosis aphasia were recruited from a second hospital, the Medical Center Rijnmond Zuid. Three patients were female and one patient was male. All had a left hemisphere infarction and mean age was 65 years (sd 17).

Semantics appeared to be the most sensitive, with a sensitivity of 62% at the optimal cut-off score, as compared with 54% and 42% for Phonology and Syntax. Specificity was 100% for all subtests. Accuracy was high for Semantics and Phonology, as indicated by the area under the ROC-curves (0.84 and 0.87) (Figure 3), but for Syntax, the area under the ROC-curve was 0.64 (Table 2).

Five patients (29%) had a selective deficit: three patients scored below cut-off on Semantics (cases 8-10) and two on Phonology (cases 6 and 7) (Table 3).

Overall, the mean Phonology score was significantly higher than the mean Semantics score (mean difference = 2.17, 95% CI = 0.28; 4.05) and the mean Syntax score (mean difference = 3.17, 95% CI = 1.16; 4.72).

Figure 2. ROC curve of ScreeLing overall score (n = 63)

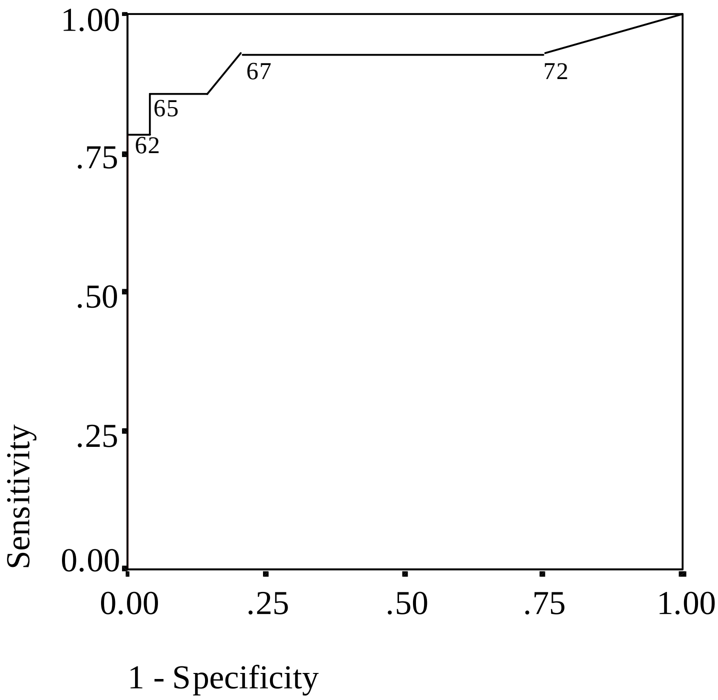


Table 2. Sensitivity, specificity and accuracy of ScreeLing subtests in 17 patients with aphasia

	No with deficit	No without deficit	Median score (sd)	Optimal cut-off point	Sensitivity	Specificity	Accuracy
Semantics (max 24)	13	4	19 (4.9)	18	62%	100%	0.84
Phonology (max 24)	13	4	21 (4.5)	20	54%	100%	0.87
Syntax (max 24)	12	5	18 (5.4)	13	42%	100%	0.64

Figure 3. ROC curves of ScreeLing subtests (n = 17)

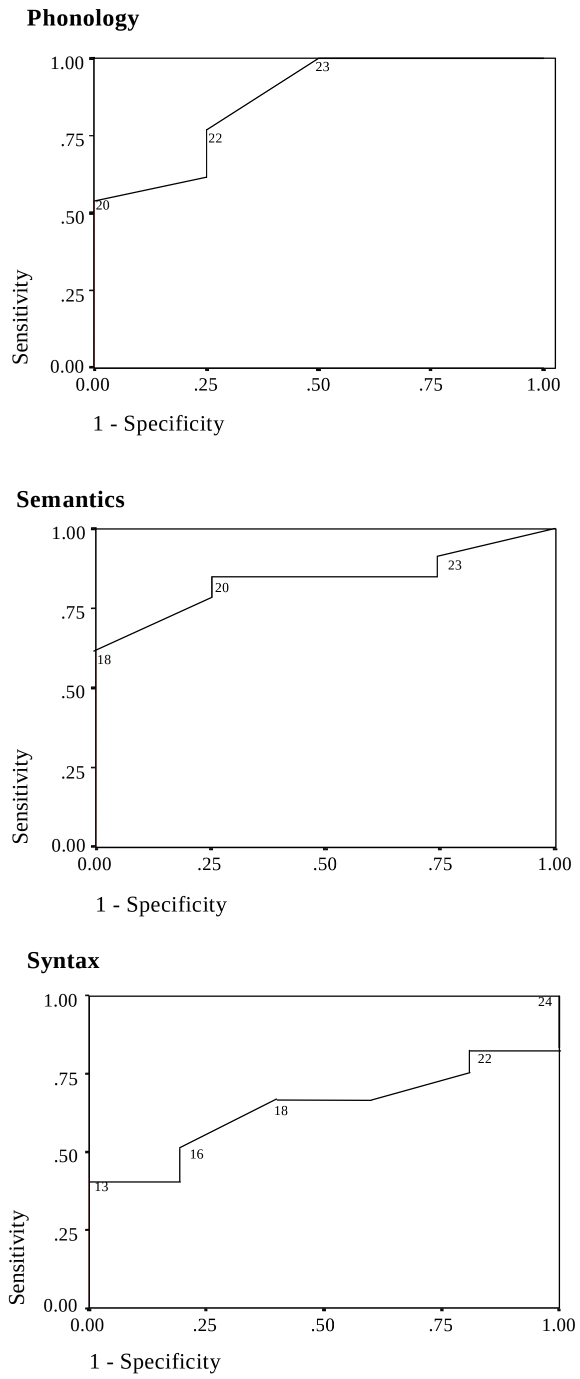


Table 3. ScreeLing subtest scores in 17 patients with aphasia

PT nr.	Semantics (cut-off: 18)	Phonology (cut-off: 20)	Syntax (cut-off: 13)
1	13	18	9
2	8	19	9
3	12	8	9
4	9	12	9
5	15	18	12
6	21*	15	14*
7	19*	20	18*
8	17	21*	18
9	18	22	15
10	16	23	20
11	23	23	21
12	22*	24*	23*
13	24*	23	24
14	19	21	20*
15	19	22	18
16	20	23*	19*
17	24	24*	24

Patient-numbers in italic refer to patients from Medical Center Rijnmond Zuid; values in bold are equal to or below cut-off.
* reference diagnosis (judgment linguist) = no deficit at this linguistic level

Discussion

In this study, we found that the ScreeLing is an accurate test to detect aphasia between 2 and 11 days after stroke. The ScreeLing, which examines three linguistic levels, is very sensitive and specific and even exceeds aphasia screeningtests that are based on a more general approach (FAST, Al-Khawaja et al., 1996; UAS test, Thomessen et al., 1999). Only two patients (4%) who failed on the ScreeLing had a reference diagnosis 'no aphasia'. These patients were 4 and 8 days post onset, thus within our group of patients (mean number of days post onset: 5), they were not the patients who were most acute and supposedly most influenced by post stroke confounding variables. Two patients (14%) had a ScreeLing-score above cut-off (65/72), whereas their reference diagnosis was aphasia. According to the linguist and the neurologist, these patients suffered from mild aphasia. This could not be detected by the ScreeLing, nor with the Tokentest, one of the most reliable tools for diagnosing aphasia (Boller & Dennis, 1979; De Renzi & Vignolo, 1962; Van Harskamp & Van Dongen, 1977). In order to detect mild aphasia, observations of hesitations, self-corrections and performance in stress-full situations (e.g. speeded naming) should be taken into account. These aspects were not included in the ScreeLing, because screening tests require unequivocal tasks that are easy to administer and score. Furthermore, there may not be an indication for disorder-oriented language therapy for patients with deficits that remain undetected after formal testing; more research on the recovery pattern of mild aphasia is needed.

Aphasia screening tests are applicable for only a limited proportion of the acute stroke patients, mainly because many patients either die or recover early. Of the eligible stroke-patients, only 61% had the mental and physical strength to participate in the assessment in our study, despite the fact that the ScreeLing takes only 15 minutes to administer. Laska et al. (2001) could assess a larger percentage of their acute stroke patients (90%). Perhaps their inclusion was more selective (inclusion criteria were not reported), or less severe patients were admitted to their hospital.

The ScreeLing not only is an accurate test for detecting aphasia, but also provides information on the patients' linguistic abilities. The tests for assessing deficits at the linguistic levels (e.g. PALPA (Kay, Lesser, & Coltheart, 1992) that were available so far, are time-consuming and therefore not suitable for use in the early phase of stroke. The ScreeLing consists of three subtests, each assessing processing at one linguistic level: Semantics, Phonology, Syntax. These subtests were validated against the judgment of an experienced linguist with respect to the presence or absence of a semantic, phonological and/or syntactic deficit. Semantics and Phonology point out to have a good diagnostic accuracy. At the optimal cut-off point (i.e. maximising the sum of sensitivity and specificity), specificity of these subtests is perfect, but sensitivity is relatively low. The best cut-off point for clinical use may differ from the 'optimal' cut-off point, for example if sensitivity is judged to be more important than specificity. For Semantics all task-types (see description in the Appendix) contributed to the diagnostic accuracy (error-rates varied from 12 to 35%). For Phonology, mainly Phon 1 (repetition) and Phon 2 (reading aloud) were responsible for predicting the presence of a phonological deficit (error rates: 18 and 35%), whereas Phon 3 (reading backwards) and Phon 4 (auditory lexical decision) turned out not to be very useful (error-rates respectively 65% and 59%). The subtest for syntax is less accurate; some patients who have a syntactic deficit according to the linguist, score above cut-off on this subtest. Error-analysis is needed to get more insight into the reasons for discrepancy between the results of the ScreeLing and the judgment of the linguist. A first analysis revealed that for only one task-type within Syntax, Syn 4 (repetition of sentences), the error-rate was low enough (24%) to be useful for predicting a syntactic deficit; the other question-types had an error-rate of 41%.

The mean Phonology score was higher than the mean Semantics score and the mean Syntax score. It is possible that Phonology was easier than Semantics and Syntax or less strenuous to patients. Alternatively, phonological deficits may be more rare than semantic and syntactic deficits. At present, data about the frequency of occurrence of linguistic disorders in an early stage of aphasia are lacking.

From our patients' subtest scores, we conclude that the performance on the three subtests was diverse, which shows that selective linguistic disorders may be detected already in the acute phase. This finding is in line with a study by Van Zandvoort (2001), showing that neuropsychological screening in the acute phase of stroke may reveal specific disorders.

In conclusion, the ScreeLing is an accurate test for detecting aphasia between 2 and 11 days after stroke. Unlike other screening-tests, the ScreeLing is suitable for revealing deficits at the main linguistic levels, especially semantic and phonological deficits. This is important for guiding early aphasia therapy, the importance of which is increasingly recognized (Robey, 1998; Robertson & Murre, 1999). For the remedying of each of these deficits, well-evaluated therapeutic tools are available (Visch-Brink, Bajema, & van de Sandt-Koenderman, 1997; Thompson, Shapiro, & Roberts, 1993; Robson, Marshall, Pring, & Chiat, 1998). Knowledge of the degree and rate of recovery of each linguistic deficit will affect early therapeutic decisions with respect to which linguistic deficit should be treated and when. In a follow-up study, we are currently investigating the degree and rate of recovery of linguistic deficits from the acute phase of aphasia until 6 months post onset. Subsequently, item analysis will be performed and the ScreeLing will be adjusted to increase diagnostic accuracy.

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Appendix

ScreeLing
The ScreeLing is designed to take about 15 minutes to administer and has a simple right-or-wrong scoring system. The test consists of 3 subtests, each with four tasks:

Semantics (24 items)
Sem 1: word-picture matching (oral and written) with distracters from the same semantic field
Sem 2: judgment of anomalous and non-anomalous sentences
Sem 3: verbal semantic association
Sem 4: choosing odd-word-out

Phonology (24 items)
Phon 1: repetition of words with an increasing phonological complexity and word length
Phon 2: reading aloud of words with an increasing phonological complexity and word length
Phon 3: reading backwards of short words
Phon 4: auditory lexical decision

Syntax (24 items)
Syn 1: sentence-picture matching
Syn 2: judgment of syntactic correctness
Syn 3: selecting the syntactically correct sentence
Syn 4: repetition of sentences consisting of mainly function words

3

The impact of linguistic deficits on verbal communication

Introduction

Aphasia has a large impact on a person's life, often turning everyday communicative situations into a struggle to understand and be understood. Improvement of the communicative ability in daily life of persons with aphasia is the main goal of aphasia therapy. This may be achieved in several ways, largely depending on the type and severity of aphasia. The intervention may involve counselling of relatives and training of alternative communication strategies. For persons with prominent linguistic level disorders at least part of aphasia therapy is spent on the main linguistic skills: semantic, phonological and syntactic processing (e.g. Schwartz, Saffran, Fink, & Meyers, 1994; Miceli, Amitrano, Capasso, & Caramazza, 1996; Nickels & Best, 1996; McNeil et al., 1997; Thompson et al., 1997). However, the relationship between these linguistic levels and verbal communication is not straightforward. This is especially true for deficits at the word-level: semantic and phonological disorders. For the selection of appropriate linguistic therapy, it is important to explore the relationship between semantic and phonological deficits and verbal communication.

Both deficits arise at a different level of language processing, and it is likely that the stage of processing at which the breakdown occurs, determines the influence on verbal communication. The verbal output of a person with a lexical semantic disorder is characterised by semantic paraphasias and empty, meaningless fillers (generalisations) which replace specific content words. Among the semantic paraphasias, 'shared feature' errors and 'associative' errors are frequently found (Nickels & Howard, 1994). Shared feature errors occur most often and arise from underspecification of the semantic representation (Nickels, 1997): the paraphasia shares some but not all elements of the semantic specification with the target (e.g. 'apple' becomes 'pear'). Generalisations and semantic paraphasias change the original meaning of the target they replace. Although the impact of semantic paraphasias on verbal communication has hardly been examined, it is clear that they will give rise to misunderstandings.

Errors at the phoneme-level seem to give more clues for the detection of the target word. In case of phonemic paraphasias, which result from an erroneous selection and/or sequencing of phonemes, the phonological structure of the target word is partially available. The target word is often recognisable. Moreover, in the context of a pure disorder at the phoneme level self-corrections are observed (e.g Kohn & Smith, 1992).

These differences between phonological and semantic errors give reason to suppose that a semantic disorder has more impact on verbal communication than a phonological disorder. However, this effect may be less clear-cut, due to several factors influencing the relative impact of both disorders on verbal communication. First, the severity of the disorder will be decisive for the recognisability of the target words. In severe conduction aphasia, phonological neologisms may arise, from which it is difficult to detect the target word (Dubois, Hecaen, Angelergues, Maufras de Chatelier, & Marcie, 1964). In severe Wernicke's aphasia, phonemic jargon is as incomprehensible as semantic jargon (Perecman & Brown, 1981; Butterworth, 1979, 1985). Furthermore, a combination of semantic and phonological disorders may lead to a two-stage error: a semantic paraphasia in combination with a phonemic error, that makes the production neologistic and unrecognisable (Buckingham, 1981). In this way, two mild linguistic deviations may result in a severe communicative problem.

Second, when considering the differential influence of semantic and phonological disorders, the yes-or-no supramodality of the disorder is an important factor. Traditionally, a lexical semantic disorder is assumed to be supramodal. The semantic system is thought to be central to all aspects of language and is involved in the comprehension and production of words, either spoken or written (Patterson & Shewell, 1987). Dysfunctioning of the semantic system will be demonstrated by both expressive and receptive semantic measures, assessing the same underlying deficit (Nickels & Howard, 1994; Raymer & Rothi, 2000). However, this concept of one semantic system subserving both production and comprehension has been under discussion. Persons with aphasia have been described who show good naming despite semantic comprehension problems (Kremin, 1986, 1988; Kremin, Beauchamp, & Perrier, 1994). Hart & Gordon (1990), who also found a selective disorder in 'receptive' semantics in three cases, suggested that the semantic mechanisms for comprehension and production are separable. A 'vertical' fractionation of semantic processing in input and output was also postulated by Raymer & Rothi (2000), along with the 'horizontal' fractionation that is indicated by category- and modality-specific deficits. These authors collected three contrasting cases with defective semantic activation within the output route, combined with intact semantic comprehension (Raymer et al., 1997a, b). However, descriptions of persons with selective input or output semantic deficits are rare. According to Nickels (1997, p.130), "….most patients who produce semantic errors also seem to make semantic errors in comprehension…." So, for the majority of patients, a semantic disorder is expected to have an effect on both expressive and receptive language processing.

In contrast with semantics, the phonological input and output routes are more generally agreed to be separable (Miceli, Gainotti, Caltagirone, & Masullo, 1980; Caramazza & Miceli, 1990; Romani, 1992; Nickels & Howard, 1995). This view is supported by a large amount of case-reports of persons with selective disorders in the output route in the context of intact phonemic processing of auditory verbal material (Caplan & Waters, 1995; Kohn & Smith, 1995; Willshire & McCarthy, 1996). A different position of semantics and phonology in language (central versus peripheral) is a reason to suppose that a semantic deficit has more impact on verbal communication than a phonological deficit.

The relative impact of phonological and semantic disorders on verbal communicative ability has not been directly investigated. Some insight can be gained from a study in which performance on a measure of verbal communicative ability – the Amsterdam Nijmegen Everyday Language Test-A (ANELT-A: Understandability)- is compared with performance on a language battery (Blomert, Kean, Koster, & Schokker, 1994). The ANELT-A appeared to correlate with the subtests 'Naming', 'Language comprehension' and 'Token Test' of the Aachener Aphasia Test (AAT, Huber, Poeck, Weniger, & Willmes, 1983), but not with the subtests 'Repetition' and 'Written language'[1].

Although Blomert and colleagues did not intend to explicitly investigate the contribution of semantic and phonological deficits to the prediction of the ANELT-A, their results suggest that a semantic deficit has a larger impact on verbal communication than a phonological deficit: semantic processing plays a larger role in the subtests related to communicative ability (Language comprehension and Naming) than in the unrelated subtests. The unrelated subtests, Repetition and Writing, are predominantly reproductive tasks.

In this study we explore the relative impact of semantic and phonological deficits on verbal communicative ability. The ANELT-A was selected as the measure of verbal communicative ability. Some researchers fear that the situations sampled in such a standardised test may not reflect a person's spontaneous participation and communicative ability in real-life situations. However, the ANELT-A combines important psychometric features like reliability and replicability with content and face validity (Manochiopinig, Sheard, & Reed, 1992; Blomert, Koster, & Kean, 1995). For a group of 29 persons with aphasia, the contributions of semantic and phonological measures to the prediction of the ANELT-A are compared. Patients with both a semantic and a phonological deficit, of varying severity, are included. The semantic measures are expected to contribute more to the prediction of the ANELT-A than the phonological measures.

Methods

Subjects

A total of 29 Dutch native speakers with a phonological deficit, a lexical semantic deficit and a moderate/severe verbal communicative deficit entered the study. The severity of each deficit varied: some persons had a severe semantic deficit and a mild phonological deficit, whereas the opposite pattern could be observed in other persons (see table 1).

For example, persons with a mild semantic deficit may score below cut-off on only one out of three receptive semantic tasks (see table 2 for language selection criteria). Persons with severe dysarthria, illiteracy or severe developmental dyslexia were excluded, as well as persons with a visual perceptual deficit. The demographic features of the subjects were as follows: mean age, 62 years (range 43-83); aetiology, three haemorrhage and 26 infarction; time post onset, 3-5 months; 12 subjects were female and 17 male. All persons with aphasia were right-handed and had had a left-hemisphere stroke. We included persons of various

[1] "Written Language" includes Reading aloud, Putting together words and sentences to dictation from letters and words and Dictation

Table 1 Performance-scores and type of aphasia

Patient	Semantic measures				Phonological measures				ANELT-A (max. 50)	Type (ALLOC)
	AAT semantic (max. 5)	Word-fluency Categories	Semantic Assoc.Test (max. 30)	Synonym Judgement (max. 60)	AAT phonology (max: 5)	Word-fluency Letters	AAT Repetition (max. 150)	Repetition nonwords (max. 24)		
1	3	8	26	54	4	9	55	5	33	Wernicke
2	3	1	11	42	3	1	83	10	29	Wernicke
3	3	5	20	53	4	0	36	4	19	Wernicke
4	2	0	22	46	4	4	112	17	26	Wernicke
5	4	.	24	57	3	4	88	.	19	Wernicke
6	4	.	20	49	3	.	77	8	35	Wernicke
7	3	4	19	46	4	6	87	19	32	Wernicke
8	3	0	27	54	3	0	32	1	18	Wernicke
9	4	4	27	54	2	8	62	6	35	Wernicke
10	2	3	25	52	4	0	38	1	10	Wernicke
11	4	4	10	36	4	1	120	14	18	Wernicke
12	2	6	12	37	2	0	22	3	19	Wernicke
13	3	9	23	53	3	2	72	4	25	Broca
14	3	1	13	48	4	0	73	4	23	Broca
15	3	7	21	49	2	2	124	20	14	Broca
16	3	0	19	32	4	0	110	21	16	Broca
17	3	3	14	43	4	0	98	12	28	Broca
18	0	4	22	52	2	4	90	7	12	Broca
19	3	1	16	50	4	0	99	12	17	Broca
20	4	5	7	.	3	1	113	9	31	Broca
21	3	1	20	47	1	0	94	6	10	Broca
22	4	12	23	55	3	1	77	3	35	Broca
23	3	7	13	34	3	1	118	14	28	Broca
24	3	19	25	58	4	0	121	10	32	Broca
25	4	16	26	53	4	8	120	23	34	Not clas
26	3	4	17	39	3	1	86	7	31	Not clas
27	3	2	15	.	2	1	115	21	16	Not clas
28	4	5	22	52	4	0	123	15	33	Anomic
29	4	13	24	57	4	12	115	17	30	Anomic

missing value represents a person who is not able to / refuses to perform the test aphasic subtypes. ALLOC classification of the AAT (Huber et al. 1983, Dutch version: Graetz, de Bleser, & Willmes, 1991) 12 Wernicke's, 12 Broca's, two anomic, three not classifiable.

Table 2. Language selection criteria

		Cut-off score (max. score)
Semantics	Aachener Aphasia Test (AAT) comprehension	< 107 (120)
	At least one of the following semantic tasks below cut-off:	
	Semantic Association Test (SAT)	< 25 (30)
	Synonym Judgement (from PALPA)	< 54 (60)
	Semantic association of abstract words (from PALPA)	< 12 (15)
Phonology	Aachener Aphasia Test (AAT) repetition	< 125 (150)
	Aachener Aphasia Test (AAT) repetition or naming	> 50% phon. errors*
Verbal Communication	Amsterdam-Nijmegen Everyday Language Test (ANELT-A)	< 36 (50)

Measures

For the assessment of semantic deficits the following measures were used:

- Semantic Association Test (SAT, Visch-Brink & Denes, 1993): choosing from four concrete written words the word that is semantically closest to the target word (30 items).
- Synonym Judgement (subtest of Psycholinguistic Assessment of Language Processing in Aphasia [PALPA], Kay, Lesser, & Coltheart, 1992; Dutch version: Bastiaanse, Bosje, & Visch-Brink, 1995): judging whether two written words have about the same meaning or not. Concrete and abstract word-pairs are involved (60 items).
- Wordfluency categories: generating words belonging to one specific category (animals; professions) within 1 minute.
- AAT semantic: rating semantic paraphasias and lack of informational content during an interview on a 6-point scale.

* Phonological error: omission, addition and/or replacement of phonemes

For the assessment of phonological deficits the following measures were used:

- Repetition pseudo-words (subtest of Dutch version of the PALPA) (24 items).
- AAT repetition: repeating phonemes, words and sentences (50 items).
- Wordfluency Letters: generating words starting with a specific letter (B; R) within 1 minute.
- AAT phonology: occurrence and frequency of phonological paraphasias and neologisms during an interview on a 6-point scale.

To assess verbal communication, we selected the ANELT, scale A (ANELT-A: Understandability). Ten scenarios of daily life situations are presented to the person with aphasia, who is asked to give a verbal reaction. Example: 'You have just moved in next door to me. You would like to meet me. You ring my doorbell and say….'. Responses are rated on a 5-point scale, representing the content of the message, independent of the linguistic form of the utterances.

ANELT-A rated by experts correlates highly with a rating by naive subjects and with the Aphasia Partner Questionnaire (a significant other is asked to indicate on a 5-point scale to what extent he thinks the person with aphasia is able to verbally express what he/she intends in a number of everyday situations), indicating that the ANELT-A has strong 'ecological' validity (Blomert et al., 1995).

Statistical analyses

Predictors of verbal communication: linear regression-analysis
To test the hypothesis that a semantic deficit has a larger impact on the verbal communicative ability of persons with aphasia than a phonological deficit, linear regression analysis with the ANELT-A as dependent variable and semantic and phonological measures as independent variables was performed. The contribution of the semantic measures to the prediction of ANELT-A was compared with the contribution of the phonological measures. The regression coefficients could not be directly interpreted as an indicator for the relative contribution of a measure to the prediction, because the independent variables were not measured on the same scale. Therefore standardized regression coefficients were calculated.

Pair-wise comparison of semantic and phonological tasks: multiple linear regression-analysis
We selected both expressive and receptive semantic measures. For the expressive semantic measures -AAT semantic and Wordfluency Categories- a phonological equivalent is available. For the measures with a semantic and a phonological version, the independent contribution of each version to the prediction of the ANELT-A could be directly compared by means of multiple linear regression analysis. Both versions of a measure were included into the model as independent variables. Pair-wise

comparison of two versions of one task enabled us to control for task-specific effects (like task-difficulty). In addition, with multiple regression we controlled for the influence of the severity of the phonological deficit (for the semantic measures) or semantic deficit (for the phonological measures).

Results

Predictors of verbal communication: linear regression analysis

Linear regression analysis with the ANELT- A as dependent variable is performed for 29 persons with aphasia. Missing values: Wordfluency categories (2), Synonym Judgement (2), Wordfluency letters (1) Repetition pseudo-words (1).

Two semantic measures contributed significantly to the prediction of ANELT-A: AAT semantic ($p < .01$) and Wordfluency Categories ($p < .01$). One phonological measure was selected as a significant predictor: Wordfluency Letters ($p < .05$). See Table 3.

Table 3. Linear regression analysis with ANELT-A as dependent variable

Measures	Range	Coefficients	Standardised coefficients	Significance
Semantic measures				
AAT semantic	0-4	5.11	0.53	0.00**
Wordfluency Categories	0-19	0.84	0.50	0.01**
SAT	7-27	0.14	0.09	0.63
Synonym Judgement	32-58	0.20	0.17	0.39
Phonological measures				
AAT phonology	1-4	3.01	0.32	0.09
Wordfluency Letters	0-12	1.04	0.42	0.03*
AAT repetition	22-124	0.04	0.15	0.43
Repetition pseudowords	1-23	0.11	0.08	0.67

** $p < 0.01$
* $p < 0.05$

Pair-wise comparison of semantic and phonological tasks: multiple linear regression-analysis

Multiple linear regression-analyses with ANELT-A as dependent variable were performed for 29 persons with aphasia, investigating the predictive value of the expressive semantic measures, independent of their phonological equivalent. Missing values: Wordfluency measures (2).

Table 4 shows that the AAT-measures (AAT semantic and AAT phonology) together contribute significantly to the prediction of the ANELT-A (p < .01), explaining 33% of the ANELT-A variance, but only the semantic measure (AAT semantic) was responsible for this effect.

The Wordfluency measures together contribute significantly to the prediction of the ANELT-A (p < .01), explaining 32% of the ANELT-A variance. Again, only the semantic measure (Wordfluency categories) independently contributed to the prediction of ANELT-A. Apparently the contribution of Wordfluency letters (= the phonological version), found in the univariate regression analysis, can be explained by a correlation between Wordfluency categories and Wordfluency letters.

Table 4. Multiple linear regression analysis with ANELT-A as dependent variable

	Semantic component Standardised coefficient (significance)	Phonological component Standardised coefficient (significance)	Model performance R^2 (significance)
AAT	0.49 (0.01)**	0.22 (0.19)	0.33 (0.01)**
Wordfluency	0.39 (0.04)*	0.29 (0.12)	0.32 (0.01)**

** p < 0.01
* p < 0.05

Discussion

In this study, we examined the relative impact of semantic and phonological deficits on verbal communication in persons with both a semantic and a phonological deficit.

The hypothesis that semantic measures contribute more to the prediction of the ANELT-A (Understandability in verbal communication) than phonological measures was supported. While none of the phonological tasks contributed independently to the prediction of ANELT-A, some of the semantic measures did. The expressive semantic measures (AAT semantic and Wordfluency categories) appeared to be good predictors of the ANELT-A score, independent of their phonological equivalent. This study identifies the ability to generate semantically correct content words, both in connected speech (AAT semantic) and in isolation (Wordfluency categories), as decisive for the aphasics' verbal communicative skills. The receptive semantic tasks (SAT and Synonym Judgement) did not predict ANELT-A. This is an unexpected finding, because as we discussed in the introduction, expressive and receptive semantic measures are generally assumed to assess the same underlying deficit, from the point of view that a semantic deficit is the indispensable intermediate between language production and language comprehension.

At first glance, our results seem to suggest a dissociation between input-and output semantic processes. Because of our design, a group study, such a conclusion is too far-fetched. Moreover, a purely expressive semantic disorder, as reported by Raymer et al. in 1997 and Caramazza & Hillis in 1990 is not present in our group, as only persons with a score below normal on at least one receptive semantic task (Synonym Judgement, Semantic Association Test, Semantic association of abstract words) are included. As all our subjects have both an expressive and a receptive semantic deficit, it is probable that they have an underlying semantic deficit and not a disorder in the accessibility of the phonological representation as Caramazza and Hillis suggested for their patients with a pure semantic output disorder. For our subjects, not the presence or absence of the semantic input and output deficits, but their severity, varies.

Differences in degrees of impairments between modalities may point to a weak dissociation. "In these cases patients are often described as having a central semantic deficit and an additional output deficit in the more impaired modality. It would seem important for further research to be directed towards examining the features of these 'output' disorders and determining how frequently they occur" (Nickels, 1997, p.130). For some persons in our group, this could be the case, for example individuals 1, 8 and 9 might have an additional output deficit. However, this remains inconclusive, because information on their performance on naming, especially the errors, is needed to have a more complete picture.

The results of our study suggest that if an additional output deficit plays a role, it is related to semantic processing and not to phonological processing. Self-initiated expressive semantic processing seems to be an important factor in verbal communication, measured by the ANELT.

Another possible explanation for the difference between the expressive and the receptive semantic measures is a difference in sensitivity: perhaps the receptive semantic measures are not as sensitive as the expressive semantic measures. However, we tried to optimize the sensitivity of the receptive measures by selecting measures that require activation of specific semantic information (Raymer & Berndt, 1996): the PALPA subtest Synonym Judgment involves abstract words, and in the SAT, the distractors are strongly related to the target. Therefore, this explanation does not seem very likely. Still, for a correct interpretation of performance on semantic tasks, it is important to gather more knowledge of their sensitivity and specificity and of the processing skills required.

Perhaps the best way to improve verbal communication in persons with both a semantic and a phonological deficit is to address the deficit that has the greatest impact: the semantic deficit. In this respect, diagnosing a semantic disorder provides more valid information than a diagnosis following a classification in aphasic subtypes. The occurrence of a semantic disorder is not related to aphasia type and severity (Visch-Brink, Denes, & Stronks, 1996). The severity of the semantic disorder in relation to other deficits is also decisive. For example, for persons with a severe phonological deficit and only a mild semantic deficit, phonological therapy may be preferred. It would be interesting to investigate the relative impact of semantic and phonological deficits on verbal communication separately for this subgroup in a larger cohort.

Semantic therapy, as it is described in the literature, has been predominantly receptive (e.g. Hillis & Caramazza, 1994; Visch-Brink, Bajema, & van de Sandt-Koenderman, 1997), but recently some authors have reported positive effects of expressive semantic techniques. Examples of expressive semantic techniques are L-SAIT -generating synonyms or antonyms- (McNeil et al., 1997) or semantic feature analysis –the person with aphasia generates semantic features of a word- (Boyle & Coelho, 1995). Unfortunately, generalisation to verbal communicative skills was not always investigated. Only a few studies looked at measures more closely related to verbal communication than, for example, naming, like storytelling in response to a range of pictures. McNeil et al. (1997) studied two cases and found no generalisation.

This study is a first step towards unravelling the relationship between linguistic deficits and verbal communicative ability. This relationship could be further explored in different groups of persons with aphasia, for example persons with a selective semantic or a selective phonological deficit. In this way the influence of interactions between the semantic and the phonological deficit -that may have played a role in our group of patients- can be addressed.

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4

Effects of semantic treatment on verbal communication and linguistic processing in aphasia after stroke

Introduction

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'(Cicerone et al., 2000). Cognitive linguistic treatment aims to improve processing at the affected linguistic level, e.g. semantics (word meaning), implicitly assuming that training of basic language skills will result in improved verbal communication.

Semantic treatment is widely used for remediating word finding deficits in aphasic communication, and is reported to be more effective than phonological treatment (word sound) (Howard, Patterson, Franklin, Orchard-Lisle, & Morton, 1985; Edmundson & McIntosh, 1995). Well-designed case- and small group studies showed encouraging positive results of semantic treatment on picture naming (Howard et al., 1985; McNeil et al., 1997; Nickels, 2002). However, this finding does not necessarily imply improved everyday communication.

Improvement of verbal communication (Amsterdam Nijmegen Everyday Language Test [ANELT], Blomert, Koster, & Kean, 1995) was found in our first study, a multiple case study with a cross-over design (Visch-Brink, 1997). Half of the patients, who were all >1 year-postonset, improved after semantic treatment (BOX, Visch-Brink & Bajema, 2001) whereas none improved after phonological treatment. These findings encouraged us to evaluate the effect of BOX on verbal communication in a randomized controlled trial (Robey & Schultz, 1998).

The present study investigates the efficacy of BOX in the period when Dutch patients normally receive treatment: 3 to 12 months after onset. It would be impossible to find patients willing to take the chance of not receiving treatment in this period, we used FIKS (Van Rijn, Booy, & Visch-Brink, 2000) 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 treatment. In addition, we analyzed the effects of both treatments on specific semantic and phonological measures.

Methods

This study is an observer-blinded randomized controlled trial, reported according to the Consolidated Standards of Reporting Trials (CONSORT) statement (Begg et al., 1996). 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: 25 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, non-native speakers, or patients with dysarthria, developmental dyslexia, severe (in relation to aphasia) acquired dyslexia, or a visual perceptual deficit. Furthermore, patients with “global aphasia” or who were considered “recovered- or no-aphasia” (Aachen Aphasia Test [AAT] (Graetz, de Blesser, & Willmes, 1991) -classification) were excluded. In order 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 Tokentest 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 (i) at least one of the following semantic tasks below cut-off: Semantic Association Test (SAT,Visch-Brink, Denes, & Stronks, 1996), Synonym Judgment (Psycholinguistic Assessment of Language Processing in Aphasia [PALPA], Bastiaanse, Bosje, & Visch-Brink, 1995), Semantic Word Association of low imageability words (PALPA) and (ii) AAT-Comprehension below cut-off.

Criteria for a phonological deficit were (i) AAT-Repetition <125/150 and (ii) 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], Morris et al., 1989) and Object Recognition from the Rivermead Behavioural Memory Test [RBMT], Wilson, Cockburn, & Baddeley, 1985) and a measure of executive functioning (Weigl Sorting Test, Weigl, 1927) 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 post onset. Treatment was comprised of 40 to 60 hours of individual treatment (1½ 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; e.g. 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 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 Syllabilification, Homophones, Analysis and Synthesis.

Measures

The primary outcome measure was the ANELT, scale A (Understandability), a valid and reliable measure of verbal communicative ability (Blomert, Kean, Koster, & Schokker, 1994). 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 the 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.

Statistics

The final score and mean improvement of both groups on the ANELT were compared by means of an independent samples *t* test. Results were expressed as the difference in improvement between the 2 groups, with a 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 (>7 points) (Blomert et al., 1995) on the

ANELT was compared by means of a chi-square 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 chi-square 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-Tokentest), 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).

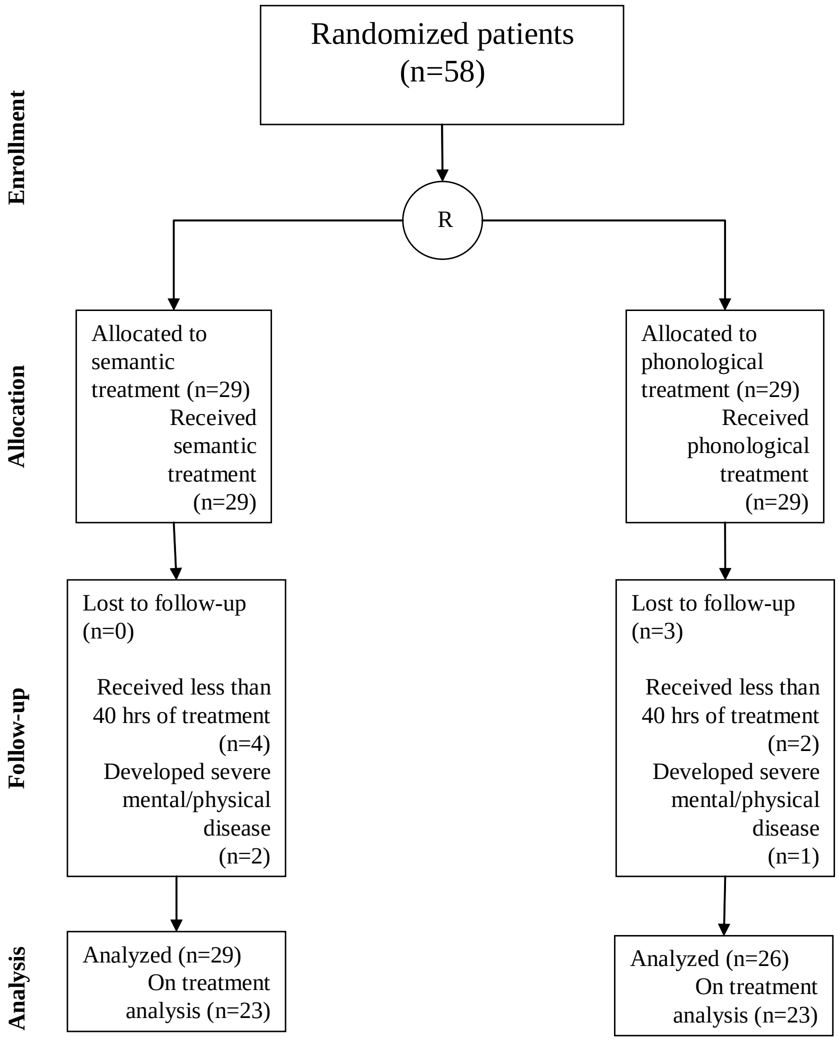
No post-treatment scores could be obtained for 3 patients: 1 patient was missed, and 2 patients refused. Of the intention-to-treat patients, 9 of 55 received less than 40 hours of treatment (range, 8 to 30 hours) for various reasons. Their post-treatment assessment occurred at the time of treatment discontinuation. 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 (Figure 1).

Table 1. Baseline characteristics.

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

EHI indicates Edinburgh Handedness Inventory (Oldfield, 1971)

Figure 1. Patient flow in the trial



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).

After semantic treatment, 34% of the patients improved significantly (>7 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).

Table 2. Comparison of ANELT-score between patients who were randomized to semantic treatment (n=29) or phonological treatment (n=26)

intention-to-treat analysis (n=55)

	Semantic Treatment (n=29)	Phonological Treatment (n=26)	Difference Mean (95% CI)
Mean final score (SD)	29.9 (12)	29.5 (11)	0.4 (-6.0; 6.9)
Mean improvement (SD)	5.1 (9)	6.2 (7)	-1.1 (-5.3; 3.1)

on-treatment analysis (n=46)

	Semantic Treatment (n=23)	Phonological Treatment (n=23)	Difference Mean (95% CI)
Mean final score (SD)	31.3 (12)	30.2 (11)	1.1 (-5.9; 8.0)
Mean improvement (SD)	6.4 (6)	6.5 (7)	-0.1 (-4.0; 3.9)

The percentage of patients who showed a clinically significant improvement (>7 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 (i.e. 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).

Table 3. Progress of on-treatment groups on semantic and phonological measures

	Mean improvement after semantic treatment (n=23) (95% CI)	Mean improvement after phonological treatment (n=23) (95% CI)	Mean difference between treatment groups (95% CI)
Semantic measures			
SAT (maximum=30)	2.9 (1.2; 4.6)*	1.6 (-0.2 ; 3.3)	1.3 (-1.0; 3.7)
Synonym Judgment (maximum=60)	1.7 (-1.1; 4.5)	0.1 (-2.3; 2.4)	1.6 (-1.9; 5.2)
Phonological measures			
Repetition Nonwords (maximum=24)	1.3 (-1.2; 3.7)	3.0 (1.4; 4.7)*	-1.7 (-4.6; 1.1)
Lexical Decision (maximum=80)	-0.5 (-2.9; 1.7)	3.0 (1.2; 4.7)*	-3.5 (-6.3; -0.7)*

* Significant difference ($p<0.05$)

Table 4. Correlations of improvement on the ANELT with improvement on semantic and phonological measures in each treatment group

	Semantic Treatment (n=23), r (p)	Phonological Treatment (n=23), r (p)
Semantic measures		
SAT (maximum=30)	.58 (.01)*	.40 (.06)
Synonym Judgment (maximum=60)	.34 (.13)	.16 (.51)
Phonological measures		
Repetition Nonwords (maximum=24)	.04 (.86)	.58 (.01)*
Lexical Decision (maximum=80)	.24 (.29)	.15 (.50)

* Significant difference ($p<0.05$)

Discussion

This study is the third randomized controlled trial (Prins, Schoonen, & Vermeulen, 1989; Katz & Wertz, 1997) 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 (Blomert et al., 1994). 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, Hellblom, Murray, Kahan, & Von Arbin (2001) 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 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, and 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 shortlived and restricted to trained items, whereas semantic techniques brought about lasting and generalized improvement (Howard et al., 1985). The superior effect of semantic treatment was in line with predictions made by the leading serial models of language processing (Morton, 1964; Doesborgh et al., 2002). The use of phonological techniques is still deemed less effective by some, despite some recent studies showing positive effects of phonological treatment (Hickin, Best, Herbert, Howard, & Osborne, 2002). Because both treatment groups showed equal improvement in our study, we conclude that phonological treatment has suffered undue neglect.

In our previous study (Visch-Brink, 1997), 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 (e.g. semantic and phonological treatment in a mixed format, Drew & Thompson, 1999, or one after the other), the optimal timing of treatment (perhaps early after onset, Doesborgh et al., 2003), the intensity of treatment (Bhogal, Teasell, & Speechley, 2003) and the efficacy of BOX and FIKS in patients with selective semantic or phonological disorders (Nettleton & Lesser, 1991). 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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5

Cues on request: the efficacy of Multicue, a computer program for wordfinding therapy

Introduction

In this study we investigated the efficacy of Multicue (Van Mourik & Van de Sandt-Koenderman, 1992; Van de Sandt-Koenderman & Visch-Brink, 1993), a computer therapy for improving word finding. Multicue uses a variety of cueing techniques to promote self-cueing strategies in aphasia. Cueing is a common technique in word finding treatment. When a person with aphasia experiences difficulties in finding a word, a semantic, phonological or orthographic cue may provide additional information and help to activate the target word above threshold (Avila, Lambon Ralph, Parcet, Geffner, & Gonzalez-Darder, 2001).

Howard & Orchard-Lisle (1984) distinguished three ways in which cueing may have an effect: 1) cues may have a direct effect (a 'prompting' effect), 2) cues may have an effect at a later point in time (a 'facilitation' effect) or 3) cues may have a permanent effect, not only on the target word, but also on other words (a 'therapeutic' effect). To achieve a 'therapeutic' effect cues should be repeatedly applied. They are often presented in a hierarchical format from least informative to most informative, e.g. first phoneme, first syllable, whole word for repetition (e.g. Hillis, 1989; Hickin, Best, Herbert, Howard, & Osborne, 2002a).

Efficacy of cueing treatments

Previous studies have shown positive effects of cueing treatments on naming. In many single and multiple case studies the long-term effect of semantic cueing treatment on naming was established, not only on trained but also on untrained items (Drew & Thompson, 1999; Coelho, McHugh, & Boyle, 2000; Wambaugh et al., 2001). The positive effects of phonological techniques have also been noted (Hickin et al., 2002a). In a review of word finding therapy, Nickels (2002) concludes that semantic and phonological techniques are effective, and she suggests that a combination of both may prove to be most effective.

As orthographic cues may assist in retrieving the phonological word form, these cues are often used in treatment. The effect of treatment based on orthographic cues is reported to be equally effective as (Hickin et al., 2002a) or more effective than (Basso, Marangolo, Piras, & Galluzzi, 2001) treatment based on phonological cues. A well-known orthographic approach involves reteaching the link between phonology and orthography to individuals with aphasia who have better written than spoken naming. Once grapheme-phoneme conversion is relearned, the person with aphasia can use the available orthographic information to generate his own phonological cues. This strategy can be applied to any word, and therefore generalisation to untrained words is expected (Nickels, 2002).

The effect of cueing treatments on verbal communication is unknown. It is often implicitly assumed that improved performance on a naming task brings about improved verbal communication, but this is hardly supported by research. Of over 50 studies investigating the efficacy of impairment-oriented word finding treatment, only a handful explicitly looked at generalisation to spontaneous speech, with contradictory results (Boyle & Coelho, 1995; McNeil et al., 1997; Franklin, Buerk, & Howard, 2002; Hickin, Herbert, Best, Howard, & Osborne, 2002b; Doesborgh, van de Sandt-Koenderman, Dippel, van Harskamp, Koudstaal, & Visch-Brink, 2003).

Although much is known about the efficacy of different cueing techniques on naming, it is not fully understood which cues are suitable for which individuals. There is no simple one-to-one relationship between the loci of impairment and the cues that will facilitate word finding: semantic techniques can improve naming for individuals with good semantic processing (Nickels & Best, 1996) and phonological tasks can improve naming for individuals with semantic impairments (Raymer, Thompson, Jacobs, & Le Grand, 1993; Nickels, 2002). Multicue's approach to tailoring therapy to the individual is to supply persons with aphasia with a range of different cues and encourage them to discover for themselves which cues they find most suitable (i.e. "discovery-based learning").

Multicue

The basic idea in Multicue is to let the person with aphasia experience the effect of several cues on his or her word finding problems. In a naming task, the user has to find out which cues are most helpful and to discover which information he or she may already have available. In contrast with many cueing therapies, there is no fixed, pre-conceived cueing hierarchy; instead, the user is free to select any cue.

By experiencing the success of different cues, users gain insight into which cues are most suitable to complete their partial knowledge of the word. This may enable them to develop self-cueing strategies by internalising the relevant parts of the cueing system.

Computers have been used with success for aphasia therapy in general (Stachowiak, 1993; Aftonomos, Appelbaum, & Steele, 1999) and also specifically for word finding therapy (Colby, Christinaz, Parkinson, Graham, & Karpf, 1981; Bruce & Howard, 1987; Van Mourik et al., 1992; Deloche, Ferrand, Metz-Lutz, Dordain, & et al., 1992; Fink, Brecher, Schwartz, & Robey, 2002). Several studies comparing computer therapy to therapist-delivered therapy found comparable effects (Kinsey, 1990; Van de Sandt-Koenderman et al., 1993). An important advantage of computer programs is that they allow the user to work independently and to decide how much time to spend on a particular word without being judged by the therapist. Multicue thus enables the aphasic user to control his or her own word-finding process.

In a previous study, three of four participants with chronic aphasia improved their oral naming of untrained items by 10-20% after treatment with Multicue for 3-6 weeks, whereas none of the participants showed better results after the paper-and-pencil version of the same therapy, provided by a clinician (Van Mourik et al., 1992).

In this study, we have investigated clinically relevant effects of Multicue in a group of persons with naming disorders. Their gains on naming and everyday language were contrasted with the gains of an untreated control group. As Multicue takes a strategic approach, we neither aimed at nor expected an improvement that was confined to the items used in therapy; the learned strategies were supposed to be independent of the particular words used in therapy and consequently should have an effect on untrained words and modalities as well. We therefore hypothesized that training with Multicue, a program with written cues and written feedback, would result in improved oral naming of untrained items, with generalisation to verbal communication.

Methods

Subjects

Persons with aphasia after stroke who had completed intensive impairment-oriented (semantic or phonological) therapy were asked to participate in this study. They were included in the study if they met the following inclusion criteria: age 20-86, native Dutch speaker, no developmental dyslexia or illiteracy, no global aphasia or rest-aphasia, at least 11 months post stroke onset, and a moderate/severe naming deficit (Boston Naming Test < 120 out of 180, Dutch scoring system, Van Loon-Vervoorn, Stumpel, & De Vries, 1995, see appendix A). Informed consent in writing was obtained from all participants or from close relatives. The local Medical Ethics Committee approved the study.

Design

Participants were randomly assigned to the experimental group or to the control group. The allocation sequence was computer generated and concealed in sequentially numbered opaque sealed envelopes until randomisation. The experimental group received 10-11 hours of treatment with Multicue in sessions of 30-45 minutes with a frequency of two to three times a week in a period of approximately 2 months. Apart from the assigned language therapy, no other therapy was allowed, except psychosocial group therapy aimed at coping with the consequences of aphasia. Treatment was delivered by the therapist who referred the participants. The control group received no treatment for 6-8 weeks.

Treatment

Multicue comprises four series of 80 pictures that are randomly presented. The program offers high and low frequency words of varying length (one to four syllables). A coloured picture is presented, and when the users are unable to find the target word, they may select one of the options in the main menu (see Appendix B for more details):

- semantic cues: “Word meaning”
- orthographic cues: “Word form”
- sentence completion: “When do you use it”
- distraction: “Take a break”

While exploring these options, users are expected to check systematically what they already know about the meaning or form of the target word. As a second step, cues can be activated.

During the first four sessions, the therapist follows a protocol to familiarise the user with Multicue. In the first session, only the orthographic menu is activated. The other cues are introduced in the second and third sessions. In the fourth session, all cues are available and the user is encouraged to try as many cues as possible, in order to discover which cues are helpful. He or she is shown how to check whether the word is correct by selecting the button “I know the word”. No specific response is required. Users may compare their spoken, written or thought response with the computer-generated written target. When relevant, synonyms are supplied. When the user gives a correct written response, positive reinforcement is given.

After the fourth session, therapist involvement is reduced. However, he/she checks regularly how the participant progresses and whether the user is “stuck” on one particular cue that is not helpful (in which case this cue can be de-activated by the therapist).

To ensure correct application of the therapy programs, the researchers regularly discussed the content of therapy and problems of application with the therapists.

Assessment

Before and after therapy the participants were assessed by the researchers. The primary outcome measure was the Boston Naming Test (Kaplan, Goodglass, & Weintrab, 1983), consisting of 60 pictures. Some of our subjects had severe word finding problems and were blocked during the administration of the test. In those cases, assessment could be terminated at 15 items, 30 items, or 45 items (pre- and post scores were based on the same number of items). Each response is scored on a 4-point rating scale (Van Loon-Vervoorn et al., 1995) (See Appendix A).

Verbal communicative ability was measured with the Amsterdam Nijmegen Everyday Language Test (ANELT, Blomert, Kean, Koster, & Schokker, 1994; Blomert, Koster, & Kean, 1995), scale A (Understandability). The ANELT-A is a valid and reliable measure in which verbal responses in 10 situations are scored on a 5-point scale for information content.

Statistics

We estimated that a sample size of 2x10 patients would provide a power of more than 70%, assuming a difference of 18 points in mean improvement on the BNT between the treated and the untreated group and a standard deviation of 16.

The null-hypothesis, i.e. no difference in mean improvement on the BNT and ANELT-A between the Multicue group and the no-treatment group, was tested with an independent samples *t*-test. T-based confidence intervals (CI) are reported. Furthermore, the difference between pre- and post therapy scores on the BNT and

ANELT-A was compared by means of a paired samples *t*-test for each group. An alpha level of .05 was used for all statistical tests.

Results

A total of 19 persons with aphasia entered the study; 10 were randomized to no treatment and 9 to Multicue. One participant in the Multicue group was lost to follow-up due to illness. The groups did not differ with respect to age, sex, handedness, time post onset, type and site of lesion, BNT-scores, ANELT-A scores, performance on the Weigl Sorting Test (a measure of executive functioning, Weigl, 1927) or content of previous treatment (semantic or phonological). See Table 1 for pretherapy characteristics of participants.

Table 1. Characteristics of participants

	Multicue n = 8	No treatment n = 10
Mean age (SD)	62 (9)	65 (12)
Male sex, n	4	5
Mean time p.o. inclusion (range), mo	13 (11-16)	13 (11-17)
Aetiology		
infarction	7	10
haemorrhage	1	
Location of strok (left hemisphere), n	8	10
handedness		
right	7	10
left	1	
BNT (max = 180), mean (SD)	63 (37)	74 (35)
ANELT-A (max = 50), mean (SD)	34 (9)	29 (12)
Previous treatment		
semantic	5	5
phonological	3	5
Executive function: Weigl Sorting Test (max = 15), mean (SD)	6 (2)	5 (2)

BNT: Boston Naming Test
ANELT-A: Amsterdam-Nijmegen Everyday Language Test, scale A

The mean BNT-score did not improve for the participants receiving no treatment (*t* (9) = 0.31, *p* = 0.76 (2-tailed), but the participants receiving Multicue improved their scores significantly (*t* (7) = 3.00, *p* = 0.02 (2-tailed). The mean ANELT-score did not improve for the participants who received no treatment (*t* (9) = 1.40, *p* = 0.19 (2-tailed), nor for the participants receiving Multicue (*t* (7) = 0.27, *p* = 0.80 (2-tailed). Mean improvement did not differ between the groups, neither for the BNT (95% CI: - 4.5 to 26.1), nor for the ANELT-A (95% CI: -2.4 to 9.4) (See Table 2).

Table 2. BNT and ANELT-A scores of participants who were randomized to Multicue (n=8) and to no treatment (n=10)

	Multicue mean (sd)	No treatment mean (sd)	t (df)	p (2-tailed)
BNT score pre-treatment (max = 180)	63.1 (36.9)	74.0 (34.9)	0.64 (16)	0.53
BNT score post-treatment (max = 180)	75.6 (38.7)	75.7 (36.7)	0.00 (16)	1.0
BNT mean improvement	12.5 (11.8)	1.7 (17.4)	-1.50 (16)	0.15
ANELT-A score pre-treatment (max = 50)	33.9 (9.2)	28.6 (12.2)	-1.0 (16)	0.33
ANELT-A score post-treatment (max = 50)	34.3 (8.4)	25.5 (10.3)	-1.95 (16)	0.07
ANELT-A mean improvement	0.4 (4.0)	-3.1 (7.0)	-1.25 (16)	0.23

BNT: Boston Naming Test; ANELT-A: Amsterdam-Nijmegen Everyday Language Test, scale A

Discussion

In this study, persons with chronic aphasia improved significantly on oral naming of untreated items (Boston Naming Test) after working with Multicue for a short period with minimal therapist involvement. Participants who received no treatment did not improve, and the comparison of the difference in improvement between treated and untreated participants suggested a beneficial effect of Multicue in this small study. The effect on oral naming was achieved by means of written cues and written feedback in therapy[2], a cross-modal effect in line with previous findings (Van Mourik et al., 1992; Deloche et al., 1992; Nickels, 2002; Fink et al., 2002).

The question is, what is the underlying cause of the improvement, particularly

[2] and perhaps written and/or oral naming: the user is not required to produce the word, but may choose to do so.

whether the users had learned to cue themselves, or Multicue had improved the process of word finding. Our data do not provide an answer to this question, because the treatment protocol did not include detailed observations of participants during treatment and assessment. Moreover, self cueing is difficult to assess, because it may occur without being observed in the speaker's behavior. However, some single case studies report observations that support either interpretation of their findings.

A person with aphasia who learned to cue himself was described by Nickels (1992). He had better written naming than oral naming and was taught to find the first grapheme of a word and to pronounce the corresponding sound. Subsequently, the participant was encouraged to incorporate this grapheme-phoneme conversion skill into a naming strategy. The participant was observed to be overtly using the first phoneme as a self-cue after treatment.

On the other hand, Robson, Marshall, Pring, & Chiat (1998) reported a positive effect of a cueing treatment on the process of word finding. They encouraged their participant to reflect upon the syllabic structure and first phoneme of pictured targets. Subsequently, she was asked to use this partial phonological knowledge as a self-cue. Naming performance improved, also for untreated items. Because the participant was not observed to make use of self-cueing, neither overt nor covert (hesitations), the authors concluded that the treatment had led to improved phonological access, rather than an ability to self-cue.

Contrary to our hypothesis, improvement on the BNT did not generalise to verbal communication as measured with the ANELT-A. More sensitive measures may be needed to detect the effect of improved word finding on verbal communication, for instance the number of content words in conversation, a measure that was shown to be strongly related to picture naming (Hickin, Best, Herbert, Howard, & Osborne, 2001).

Alternatively, the gap between naming and verbal communication may be unbridgeable for some patients. It is increasingly recognized that non-linguistic cognitive deficits may have a large influence on the efficacy of aphasia therapy. Deficits in executive functioning are offered as possible explanations for why the abilities trained in therapy do not generalise to everyday life (Helm-Estabrooks & Ratner, 2000; Purdy, 2002). Non-linguistic cognitive deficits may certainly have played a role in our study; performance of the participants on a test of executive functioning (Weigl Sorting Test) was relatively low. These deficits may not only have prevented generalisation to everyday communication, but they may also have influenced the effect of Multicue on naming. The learning principle of Multicue, i.e. discovery-based learning, is likely to require more of users in terms of executive functioning than drill and practice. Users have to discover by themselves which cues are most useful to them. They have to keep the different cues and their effectiveness in memory and compare them, and flexibly shift to another cue when the chosen cue is not helpful. It is possible that many persons with aphasia who have poor executive functions would benefit more from an approach that requires less flexibility. Presenting the cues in a fixed order, and not asking the user to choose between different cues, but to check them all, may be a better approach for people with cognitive limitations. It may be easier to internalise a fixed procedure that can be used in communicative situations. This was observed by Christinaz (personal communication in Katz, 2001). Participants worked with a computer that displayed a fixed series of questions each time they experienced word finding problems. “Patients reported after several weeks of using the computer, that they no longer required it, instead asking themselves the same series of questions previously displayed by the computer. Christinaz reasoned that the participants had internalised the algorithm and now cued themselves without the need of external prompts.” (Katz, 2001). A study in which this approach (i.e. learning focused on internalising a fixed set of cues) is compared with the Multicue approach (i.e. discovery-based learning) may be relevant for clinical practice.

The results of our study are encouraging, especially in view of the fact that although the participants were more than a year post stroke onset and had already received intensive impairment-oriented treatment, they further improved their naming ability with Multicue therapy. Moreover, this effect was found after only 10 hours of treatment. This is a minimal amount of therapy according to Bhogal, Teasell, and Speechley (2003), who in their review found that studies that showed an effect of aphasia therapy provided 93 (60-120) hours of therapy in 11 (8-12) weeks, whereas studies that showed no effect provided 44 hours (30-52) of therapy in 23 (20-26) weeks. Future studies need to establish whether more intensive Multicue treatment leads to larger effects on naming and possibly generalisation to verbal communication.

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Appendix A. Scoring Boston Naming Test

3 points
correct or correct with phonological or dysarthric distortion (at least 2/3 correct)

2 points
self-correction, long hesitation, correct word used in a sentence, semantically closely related word (e.g. category name / second part of a compound), good description

1 point
semantically related word (unspecific category name / first part of a compound), reasonable description.

0 points
semantically unrelated word, bad description, neologism, automatism, perseveration, no response, avoidant phrase, wrong interpretation based on perceptual commonalities (including naming of a part of the picture)

Appendix B. Options and cues in Multicue

Main menu	**Submenu**
Word meaning	Features (e.g. form, category, function, location) Semantic associations Description Drawing (to be made by user)
Word form	First letter Number of syllables and stresspattern Last letter
Sentence completion ("When do you use it")	
Distraction ("Take a break")	(contains 11 melodies)

6

General discussion

In the past decennia, significant progress has been made with respect to assessment and treatment of wordfinding deficits in patients with aphasia, as shown by the development of language models (e.g. Ellis & Young, 1988; Patterson & Shewell, 1987), measures (e.g. SAT, Visch-Brink & Denes, 1993; PALPA, Bastiaanse, Bosje, & Visch-Brink, 1992; VAST, Bastiaanse, Edwards, Maas, & Rispens, 2003) and treatments showing positive effects on naming performance in phase 1 and phase 2 studies. However, there is still a lot to be learned in order to improve the patients' everyday communication. This thesis has added to the knowledge of assessment and treatment of wordfinding deficits.

A linguistic screening test that can be applied early post stroke was found to be an accurate diagnostic tool. Furthermore, we found that semantic deficits have a larger impact on verbal communication than phonological deficits. In another study, we concluded that phonological treatment has suffered undue neglect, since we found equal effects of semantic and phonological treatment on a measure of verbal communication. Finally, we obtained promising results with a computerized treatment that contains semantic and phonological cues.

Though these results answer some questions, they also invoke some new ones. In this chapter, I will discuss some of the questions that are important for optimizing aphasia treatment, and will do so against the background of the previous chapters of this thesis and two models presented below. I conclude with suggestions for future research that may bring us closer to the optimal treatment for wordfinding deficits in aphasia.

Models

A model by Robertson & Murre (1999) describes processes that presumably take place at the neural level in patients recovering from brain damage. Brain damage can be described as damage to a neural network -i.e. neurons and connections between neurons- involved in a specific cerebral function, like some aspect of language processing. In addition to this direct damage, intact neurons in the damaged network may be inhibited by nondamaged networks. Furthermore, in nondamaged networks that are connected to the damaged one there may be depression of activity, as these networks receive less input (diaschisis). Neurons that are inactive due to inhibition or diaschisis may die (decay) if they are inactive for a long time.

By repeatedly activating the remaining neurons at the same time, there is an increase in or strengthening of connections between the remaining neurons in and around a damaged network (Hebb 1949). Increased connectivity may make up for the cells that are lost. This process is called restitution.

For larger lesions, restitution is not possible, as too little (or no) neurons and connections of a certain network remain. However, other networks that originally did not carry out the lost function and that are often far apart from the damaged network (for example the homologous part in the nondamaged hemisphere) may take over: compensation.

Code (2001) integrated processes at the neural level with processes at the cognitive and behavioral level, which leads to several suggestions with respect to the optimal timing of treatment and the type of treatment that is likely to be most successful.

According to this author, the processes of restitution and compensation take place at the neural, cognitive and behavioral level. At the cognitive level, restitution takes place if the basic function, e.g. phonological processing, recovers. With impairment oriented treatments like BOX or FIKS, restitution of function is attempted. Compensation takes place if this function is carried out in a different way than previously. For example, we expect that after treatment with Multicue, basic functions such as phonological processing, involve an additional step (self-cueing). Nevertheless, we argued that it is difficult to investigate whether this has indeed happened, or whether restitution has taken place.

At the behavioral level, one could think of recovery of verbal communication as restitution, and of using nonverbal communication techniques, like gesture and drawing, as compensation.

Implications for treatment

Restitution or compensation?

If at the neural level compensation has taken place, recovery of function is usually less complete than with restitution (Cao, Vikingstad, George, Johnson, & Welch, 1999). Compensation may even have unwanted effects, e.g. when networks taking over inhibit the impaired network, thereby preventing any chance of restitution. This is the idea behind ‘constraint-induced learning’ (Pulvermuller et al., 2001), i.e. discourage use of intact networks (in motor rehabilitation: discourage use of the unimpaired limb) and stimulate use of impaired networks (i.e. the impaired limb). Therefore, if restitution is possible, this should be attempted.

What is the best timing for treatment?

If neurons can decay, e.g. as a result of diaschisis and/or inhibition from undamaged networks, they may do so quickly following a lesion. Thus therapy with a focus on restitution like BOX and FIKS (i.e. appropriate stimulation along with the discouragement of responses that might foster faulty connections) is best delivered in the acute phase after stroke, in which restitution at the neural level can still take place. Compensation (delivering alternative means of communication) is more suitable for the chronic phases of recovery.

How can nonverbal cognitive processes be used in recovery and response to treatment?

From the model follows that in order to promote restitution, that is, increased connectivity between neurons for recovery of cognitive function, the damaged networks should be activated. General activation may be provided by stimulant drugs; this should promote recovery from diaschisis. For example, Walker-Batson et al. (2001) found that administration of dextroamphetamine paired with speech/language therapy facilitated recovery from aphasia. Activation can also be modulated by attentional circuits within the brain, which are partly based in the prefrontal cortex. The model thus suggests the importance of attentional processes in recovery from brain damage.

Attention is likely to also play a large role in verbal communicative disabilities in aphasic patients. It is assumed that in patients with brain damage the affected cognitive processes no longer take place automatically, but instead require attention. Whereas many automatic processes can take place in parallel, attention can be paid to only a restricted amount of processes at the same time. In aphasia, the amount of attention available for no-longer-automatic linguistic processes is likely to fall short of what is needed in verbal communication. By treating a linguistic deficit, linguistic processing at this level should become more automatic (i.e. require less attention), reducing processing load in verbal communication. As a consequence, verbal communication should become less effortful and more effective, whichever way the reduction in processing load is achieved (e.g. by means of either improving semantic or phonological processing).

Not only attention, but also other nonverbal cognitive processes are likely to exert a large influence on verbal communication and effects of treatment. The importance of executive functions for verbal communication was suggested by the results of the regression study described in chapter 3: measures requiring executive processes like initiative and flexibility -besides specific verbal processes- (wordfluency letters and wordfluency categories), were significant predictors of the ANELT.

Purdy (2002) stresses the importance of executive functions in generalisation of treatment to everyday life. Van Harskamp & Visch-Brink (1991) suggested that after improving basic linguistic skills, there should be a period dedicated to integrating these skills in order to produce an information-carrying message. Ten years later, Visch-Brink (1999) suggested that the latter stage may be left out, as indicated by a pilot study in which patients improved on a measure of verbal communication after semantic therapy (BOX) without having had an "integration-phase" in treatment. This was confirmed in our randomized trial investigating the efficacy of BOX (chapter 4). However, an integration-phase focused on 'bringing the message across' in a communicative setting may well be useful for the patients treated with Multicue: after Multicue patients improved in their performance on a naming task, but improvement on verbal communicative ability could not be established. Furthermore, we argued that executive functioning was essential not only for generalization, but also for profiting from Multicue-treatment in the first place, as the approach was 'discovery-based' and thus placed a large demand on executive functions. Our patients, many of whom had executive deficits, may have been able to learn within 10 hours to check a fixed set of cues each time they experience wordfinding problems instead.

One may conclude that for optimizing the effect of aphasia treatment, dealing with nonverbal cognitive deficits, either by treating them (van Harskamp et al., 1991) or by circumventing them, is important.

What are the best treatment techniques?

The model predicts that specific stimulation to the damaged network involved in a specific function should establish patterns of connectivity within the damaged network that are adaptive. Adaptive patterns need not be identical to the original patterns of activation; an alternative route (e.g. strategies learned with Multicue) may also be adaptive. In order to be able to provide specific stimulation, focused on the specific deficit (i.e. impairment oriented treatment), careful assessment to reveal this deficit is essential. It is unclear, however, which deficit should be treated if multiple deficits are present.

Two of the studies presented in this thesis provide information relevant to this issue. However, their results may at first sight appear conflicting. We hypothesized that a semantic deficit, located centrally in leading models of wordprocessing, has a larger impact on verbal communication in everyday life than a more peripherally located phonological deficit. This was confirmed in the regression study described in chapter 3: semantic measures appeared to be good predictors of the ANELT-A score, whereas phonological measures were not. We concluded that perhaps the best way to improve verbal communication in patients with both a semantic and a phonological deficit is to address the deficit with the greatest impact: the semantic deficit. However, our randomized study that compared the effects of semantic and phonological treatment on verbal communication showed that both treatments equally improved verbal communication. How can it be explained that selective treatment of the linguistic deficit with the highest impact on verbal communication does not translate itself into a better performance at the verbal communicative level?

Perhaps we were unable to pick up a therapeutic advantage of semantic treatment in the trial since a) this advantage is not reflected by the amount of effect on verbal communication, but rather in the recovery speed, b) a semantic deficit is more resistant to recovery, but even small effects have a large impact on verbal communication or c) semantic treatment should have a large expressive component in order to be optimally effective.

If indeed less therapy time is needed for semantic treatment to have an effect, than perhaps in the trial phonological treatment 'catched up' after a certain amount of therapy time. This could be the reason why in the pilot study, patients improved after semantic treatment (BOX), but no effect of phonological treatment (not FIKS) was found: in this study patients received only half the amount of treatment given in the trial.

Alternatively, a semantic deficit may be more resistant to therapy than a phonological deficit. Perhaps improvement in semantic processing after BOX was not as large as improvement in phonological processing after FIKS, but still this small improvement in semantic processing had as much impact on verbal communication as a large improvement in phonological processing.

Finally, maybe only semantic treatment with expressive semantic tasks (e.g. producing synonyms or antonyms, McNeil et al., 1997) is more effective than phonological treatment. After all, in the regression study we found that only expressive semantic measures were good predictors of the ANELT-A score. BOX, the treatment program we evaluated in the trial, consists of receptive exercises (e.g. sorting a list of words into two categories).

In summary, with respect to linguistic deficits, the models predict that it is essential to provide the patient with specific linguistic information. However, when there are more deficits, the models do not aid in choosing which of these should be treated or is most likely to be subject to remediation. More research is needed. A factor that makes future research problematic is that semantic and phonological measures are often difficult to compare in terms of difficulty and sensitivity to change. We were confronted with the same problem in our study with the ScreeLing: here the phonological subtest seemed to be easier than the semantic subtest. More knowledge on the comparability of linguistic measures is important.

Conclusion

The most promising approach to treatment should focus on restitution of function except when the lesion is too large, be based on careful assessment, and be applied in patients early post onset. Furthermore, dealing with nonverbal cognitive deficits is important. How does this thesis fit in with these requirements?

The treatments with a focus on restitution of function presented in this thesis (BOX and FIKS) were not evaluated in the period that the models suggest is optimal (i.e. early post onset): patients started treatment between 3 and 5 months post onset. It would be interesting to investigate the efficacy of these treatments in the acute phase of aphasia. Furthermore, more insight will be gained by simultaneously visualizing which of the presumed processes (restitution or compensation) are taking place in the brain and to which extent during recovery of linguistic functions. Restitution can be demonstrated by functional magnetic resonance imaging (fMRI), that may reveal whether structures known to be involved in the impaired function are activated when the relevant behavior is produced.

Though perhaps BOX and FIKS were not applied in the optimal period, the timing of our evaluation of the treatment program with a focus on compensation (Multicue), i.e. in the chronic phase of aphasia, does seem to have been appropriate.

The treatments evaluated in this thesis did not include interventions to treat or circumvent nonverbal cognitive deficits, e.g. a specific integration phase or the use of stimulant drugs. Nonverbal cognitive processing is presumably important for transfer of skills trained in therapy to the behavioral level: verbal communication.

Future research

As has become clear from this chapter, a lot of unanswered questions remain. What is the efficacy of BOX and FIKS in an early stage post onset? Can restitution at the neural level after BOX or FIKS be shown? Is in fact a treatment focused on restitution better than a treatment focused on compensation in the early stage post onset? What is the efficacy of BOX and FIKS in patients with a single linguistic deficit (i.e. either semantic or phonological)? What impact did the relative severity of each linguistic deficit have on response to treatment in the trial? Are expressive semantic exercises more effective for improving verbal communicative ability than receptive semantic exercises? Can the effects of BOX, FIKS and Multicue be increased by means of interventions focused on nonverbal cognitive processes (e.g. stimulant drugs, adding an 'integration phase') or by circumventing defective cognitive processes (e.g. simplifying Multicue)? What is the minimal amount of therapy-time needed for a treatment to be effective, and do BOX and FIKS differ from one another in this respect? How is performance on the ANELT related to verbal communicative ability as judged by a significant other? What is the recovery pattern of linguistic deficits? Fortunately research in Rotterdam does not stop with finishing the last chapter of this thesis; several new studies dealing with some of these issues are running or planned.

In a currently running study, we aim to find a profile of patients who are most likely to be able to profit from treatment focused on restitution of function (i.e. BOX and FIKS). A profile of factors predicting success with BOX and FIKS will be very useful in clinical practice. Each patient participating in the BOX/FIKS study is described according to the "axes-system" (van Harskamp et al., 1991), i.e. not only linguistic features (e.g. the relative severity of each linguistic deficit), but also neurological, neuropsychological and psychosocial features of a patient are specified. It is evident that these factors may be very important predictors. Each patient's profile is related to their response to treatment.

In another study, the relationship between the ANELT and a questionnaire filled out by a significant other (Partner-ANELT, Blomert, 1995) is investigated. Investigating recovery of linguistic functions from a few days to half a year post onset is possible with the new tool for investigating linguistic deficits in the acute stage: the ScreeLing. Data are currently analyzed.

Last but not least, a study is planned to investigate whether: a) in the acute phase, cognitive linguistic treatment is indeed more effective than treatment directed at communicative strategies and b) cognitive linguistic treatment is more effective when applied early after stroke onset (from 3-5 weeks post onset onwards). The protocol includes linguistic assessment with the ScreeLing and some semantic and phonological tasks for guiding treatment and for monitoring improvement in linguistic processing. The primary outcome measure is the ANELT. The effect of treatment will be compared with changes in activation on fMRI in the speech areas during semantic processing.

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7

Summary & Samenvatting

Summary

Aphasia is a language disturbance caused by brain damage, usually a stroke. Aphasia has a large impact on a patient's life, often turning everyday communicative situations into a struggle to understand and be understood. Improvement of these patients' communicative ability in daily life is the main goal of aphasia therapy. The verbal communicative ability of aphasic patients may be disturbed by semantic (word meaning), phonological (word form) and/or syntactic (grammatical structure) deficits. Cognitive linguistic treatment aims to improve processing at the affected linguistic level, implicitly assuming that training of basic language skills will result in improved verbal communication.

In this thesis, the relative impact of semantic and phonological deficits on verbal communication is explored. Furthermore, the results of both diagnostic and therapeutic studies in patients with aphasia after stroke are presented.

In *chapter 2*, a newly developed screening test for assessing deficits at the main linguistic levels (semantics, phonology and syntax) is evaluated. The ScreeLing's sensitivity, specificity and accuracy in detecting aphasia and semantic, phonological and syntactic deficits were determined. The ScreeLing was validated in an acute stroke population against a combined reference diagnosis of aphasia (aphasia according to at least two of the following measures: neurologist's judgment, linguist's judgment, Tokentest-score). The three ScreeLing subtests were validated in the aphasic population against the presence or absence of a semantic, phonological and/or syntactic deficit according to an experienced clinical linguist.

63 patients were included. The ScreeLing is an accurate test that can be easily administered and scored to detect aphasia in the first weeks after stroke. Furthermore, the ScreeLing is suitable for revealing underlying linguistic deficits, especially semantic and phonological deficits. The new test can be used to guide early aphasia treatment and to facilitate studies investigating the prognostic value of the presence and severity of semantic, phonological and syntactic deficits in the acute stage.

Chapter 3 discusses the relationship between performance on semantic and phonological tasks and performance on the ANELT-A, a measure of verbal communicative ability. The hypothesis was that a lexical semantic deficit has a larger impact on the verbal communicative ability of persons with aphasia than a phonological deficit. A total of 29 persons with aphasia who had both a semantic and a phonological deficit were assessed by means of semantic tasks (two expressive tasks and two receptive tasks) and phonological tasks, and a test of verbal communication (ANELT-A).

The expressive semantic measures, Wordfluency Categories and AAT spontaneous speech-semantics, contributed significantly to the prediction of ANELT-A. One phonological measure, Wordfluency Letters, was selected as a

significant predictor. However, only the semantic measures appeared to contribute independently to the prediction of the ANELT-A. The contribution of Wordfluency Letters can be explained by a correlation with its semantic counterpart. These results support the hypothesis that semantic measures contribute more to the prediction of the ANELT-A than phonological measures. We concluded that perhaps the best way to improve verbal communication in persons with both a semantic and a phonological deficit is to address the deficit wit the greatest impact: the lexical semantic deficit.

In *chapter 4* we investigated the effects of semantic treatment on verbal communication in a randomized controlled trial. 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 pre- and post-treatment assessment of verbal communication (ANELT-A). In an on-treatment analysis (n = 46), treatment-specific effects on semantic and phonological measures were explored.
Both groups improved on the ANELT-A, with no difference between the groups in the overall score. After semantic treatment, patients improved on a semantic measure, whereas after phonological treatment, patients improved on phonological measures. 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.

Finally, *chapter 5* describes a study investigating the efficacy of a computerized treatment of wordfinding problems, Multicue. Multicue is a computer program that offers a variety of cues and that stimulates the users' independency by encouraging them to discover themselves which cues are most helpful. A total of 18 individuals with aphasia caused by stroke, who had completed intensive impairment-oriented treatment, were randomized to 10-11 hours of Multicue or no treatment. Only the Multicue group improved on the Boston Naming Test. However, mean improvement did not differ significantly between the treated and untreated groups. Neither group improved on the ANELT-A. We concluded that in the chronic phase of aphasia, following impairment-oriented treatment, Multicue may have a beneficial effect on word finding in picture naming, either via improved access or via self-cueing.

I conclude with an integration of the findings in the studies described and suggestions for future research against the background of two models. One model describes processes that presumably take place at the neural level in patients recovering from brain damage. The process of increased connectivity between the remaining neurons by simultaneous activation is called restitution. The process of other networks taking over is called compensation. The other model integrates these processes at the neural level within a larger framework that also includes a

cognitive and a behavioral level, with restitution and compensation taking place at each level. The models lead to several suggestions with respect to the optimal timing of treatment and the type of treatment that is likely to be most successful, as well as suggestions for creating optimal treatment conditions.

Samenvatting

Afasie is een taalstoornis die veroorzaakt wordt door hersenletsel, meestal ten gevolge van een beroerte. Afasie heeft een grote invloed op het leven van een patiënt; vaak veranderen alledaagse communicatieve situaties in een strijd om te begrijpen en begrepen te worden. Het verbeteren van de communicatieve vaardigheden van deze patiënten is dan ook het belangrijkste doel van afasietherapie. De verbale communicatieve vaardigheden van afasiepatiënten kunnen verstoord zijn door semantische (woordbetekenis), fonologische (woordvorm) en/of syntactische (grammaticale structuur) stoornissen. Cognitief linguïstische therapie heeft als doel om de verwerking op het aangedane linguïstische niveau te verbeteren, er impliciet van uitgaand dat het trainen van basale taalvaardigheden zal resulteren in verbeterde verbale communicatie.

In dit proefschrift wordt de relatieve invloed van semantische en fonologische stoornissen op de verbale communicatie onderzocht. Bovendien worden de resultaten gepresenteerd van zowel diagnostische als therapeutische studies bij patiënten met afasie na een beroerte.

In *hoofdstuk 2* wordt een nieuwe screeningstest (ScreeLing) voor het meten van stoornissen op de belangrijkste linguïstische niveaus (semantiek, fonologie en syntaxis) geëvalueerd. De sensitiviteit, specificiteit en accuratesse van deze test wat betreft het detecteren van afasie en semantische, fonologische en syntactische stoornissen werden bepaald.

De ScreeLing werd gevalideerd in een groep patiënten in de acute fase na de beroerte, tegen een gecombineerde referentiediagnose afasie (afasie volgens ten minste twee van de volgende maten: oordeel neuroloog, oordeel linguïst, Tokentest score). De drie ScreeLing subtests werden gevalideerd in de groep afasiepatiënten tegen de aanwezigheid of afwezigheid van een semantische, fonologische en/of syntactische stoornis volgens een ervaren klinisch linguïst.

Er werden 63 patiënten geïncludeerd. De ScreeLing bleek een goede test te zijn om reeds in de eerste weken na een beroerte een afasie te diagnosticeren. Bovendien is de ScreeLing geschikt om de onderliggende linguïstische stoornissen, met name semantische en fonologische stoornissen, vast te stellen. De nieuwe test kan gebruikt worden om afasie therapie in een vroege fase na de beroerte richting te geven. Bovendien faciliteert dit instrument studies die de prognostische waarde van de aanwezigheid en ernst van semantische, fonologische en syntactische stoornissen in de acute fase onderzoeken.

Hoofdstuk 3 bespreekt de relatie tussen prestatie op semantische en fonologische taken en prestatie op de ANTAT-A, een maat voor verbale communicatieve vaardigheid. De hypothese was dat een semantische stoornis een groter effect heeft op de verbale communicatieve vaardigheid van afasiepatiënten dan een fonologische stoornis.

Negenentwintig afasiepatiënten met zowel een semantische als een fonologische stoornis werden onderzocht met semantische taken (twee expressieve en twee receptieve taken), fonologische taken en een test voor verbale communicatie (ANTAT-A).

De expressieve semantische maten, Wordfluency Categorieën en AAT spontane taal- semantiek, droegen significant bij aan het voorspellen van de ANTAT-A. Eén fonologische maat, Wordfluency Letters, kwam naar voren als een significante voorspeller. Echter, alleen de semantische maten bleken onafhankelijk bij te dragen aan de voorspelling van de ANTAT-A. De bijdrage van Wordfluency Letters kan verklaard worden door een correlatie met de semantische tegenhanger (Wordfluency Categorieën). De resultaten ondersteunen de hypothese dat semantische maten meer bijdragen aan het voorspellen van de ANTAT-A dan fonologische maten. We concluderen dat patiënten met een gecombineerde semantische en fonologische stoornis wellicht het meeste baat hebben bij een therapie die gericht is op de stoornis die de grootste invloed heeft op de verbale communicatie: de lexicaal semantische stoornis.

In *hoofdstuk 4* onderzochten we de effecten van semantische therapie (BOX) op verbale communicatie in een gerandomiseerde studie. Achtenvijftig patiënten met een gecombineerde semantische en fonologische stoornis werden gerandomiseerd voor ofwel semantische therapie ofwel de controle therapie (fonologische therapie, FIKS). Vijfenvijftig patiënten konden voor en na de behandeling onderzocht worden met een maat voor verbale communicatie (ANTAT-A). In een on-treatment analyse ($n = 46$), werden therapie-specifieke effecten onderzocht met semantische en fonologische maten.

Beide groepen gingen vooruit op de ANTAT-A, waarbij er geen verschil was tussen de groepen wat betreft de eindscore. Na semantische therapie gingen patiënten vooruit op een semantische maat, en na fonologische therapie gingen patiënten vooruit op fonologische maten. Onze bevindingen zijn in strijd met de huidige opvatting dat semantische therapie effectiever is dan fonologische therapie voor patiënten met een gecombineerde semantische en fonologische stoornis. De selectieve vooruitgang op de semantische en fonologische maten suggereert dat de vooruitgang in verbale communicatie in elke therapie-groep op een andere manier bereikt werd.

Tenslotte wordt in *hoofdstuk 5* een studie beschreven waarin de effectiviteit van een computer-therapieprogramma voor woordvindingsproblemen, Multicue, wordt onderzocht. Multicue biedt een scala aan cues en stimuleert de zelfstandigheid van de gebruikers door hen aan te moedigen om zelf te ontdekken welke cues het beste werken.

Achttien patiënten met afasie, die een intensieve stoornisgerichte behandeling afgerond hadden, werden een jaar na onset gerandomiseerd naar 10-11 uur Multicue of geen therapie. Alleen de Multicue groep ging vooruit op een benoemtaak (Boston Naming Test). Er was echter geen significant verschil tussen de gemiddelde vooruitgang van de behandelde en de niet-behandelde groep. Geen van beide groepen ging vooruit op de ANTAT-A. We concluderen dat Multicue in de chronische fase van afasie, na een periode van stoornisgerichte behandeling, een positief effect kan hebben op woordvinding in een benoemtaak; ofwel via verbeterde toegang tot het woord, ofwel via “self-cueing”.

Ik besluit met een integratie van de bevindingen en suggesties voor verder onderzoek tegen de achtergrond van twee modellen. Het ene model beschrijft processen waarvan wordt aangenomen dat ze plaats vinden op neuraal niveau bij patiënten die herstellen van hersenletsel. Het proces van in aantal of sterkte toegenomen verbindingen tussen de overgebleven neuronen door herhaaldelijke simultane stimulatie wordt restitutie genoemd. Het proces van overname door andere netwerken wordt compensatie genoemd. Het andere model integreert deze processen op neuraal niveau in een groter kader, dat naast het neurale niveau ook een cognitief niveau en een gedragsmatig niveau omvat; restitutie en compensatie treden op elk niveau op. De modellen leiden tot diverse suggesties met betrekking tot de optimale timing van therapie, het soort therapie dat het meest succesvol zal zijn, en de optimale condities voor therapie.

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Curriculum Vitae

Suzanne Doesborgh werd geboren op 13 maart 1974 te Leiden. In 1992 behaalde zij haar Atheneum B diploma aan het Christelijk College Nassau Veluwe te Harderwijk. In hetzelfde jaar startte zij haar studie psychologie aan de Universiteit Utrecht met als specialisatie "Cognitieve functiestoornissen". Haar afstudeeronderzoek heeft zij in Londen uitgevoerd bij professor Ruth Campbell en haar klinische stage liep zij in het Universitair Medisch Centrum Utrecht op de afdeling Kinderneurologie. In september 1997 studeerde zij af. Vanaf januari 1998 is zij werkzaam bij het Erasmus MC te Rotterdam, waar zij als Assistent in Opleiding begon aan dit proefschrift. Sinds september 2002 is zij werkzaam bij Meerkanten GGZ te Ermelo als neuropsycholoog / onderzoeker. Daarnaast is zij bezig de klinische BIG-registratie gezondheidszorgpsycholoog te halen.

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